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ERRATA.

Page 288, line 14 from top, for "replenished," read "furnished."

Page 341, No. 14, for the locality "Fort Washington, Virginia," read "Fort Washington, Maryland;"—and the same in the description of Fig. 31, page 343.

Page 366, line 7 from bottom, for "nucleus," read "nuclei."

Page 369, line 16 from bottom, before "errors" insert "from."

A NEW SERIES

OF THE

American Journal of Science and Arts,

Will be commenced on the first of January, 1846, when the present series of FIFTY VOLUMES will be brought to a close. The FIFTIETH VOLUME of the *Old Series* will consist of a

GENERAL INDEX

to the previous volumes, which will be published near the close of the year 1845 or as soon after as it can be prepared. This Index, the preparation of which has been often urged upon us by our scientific friends, is quite essential to the full use of the entire series of volumes, replete as they are with important papers, most of them original American productions. It will contain the fullest references to all the contents and AUTHORS of the 49 volumes which it will cover. Every subject which is mentioned in the entire series, and every author whose opinions or writings are quoted, will be mentioned, and those general principles of good arrangement adopted, which will make it easy to find the word and subject sought.

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In reference to the *New Series*, we will only say now, that there will be several important changes in it from the present one, designed to make it more valuable and important to all classes of readers. The details of our plan as far as they need be made known will be early announced. One principal motive for commencing this Series is the hope of an increase of our present *very limited* patronage.

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B. Silliman,
B. Silliman, Jr. } *Editors and Proprietors.*

New Haven, January 6, 1845.

ACKNOWLEDGMENTS TO CORRESPONDENTS, FRIENDS AND STRANGERS.

Remarks.—This method of acknowledgment has been adopted, because it is not always practicable to write letters, where they might be reasonably expected; and still more difficult is it to prepare and insert in this Journal, notices of all the books, pamphlets, &c., which are kindly presented, even in cases, where such notices, critical or commendatory, would be appropriate; for it is often equally impossible to command the time requisite to frame them, or even to read the works; still, judicious remarks, from other hands, would usually find both acceptance and insertion.

In public, it is rarely proper to advert to personal concerns; to excuse, for instance, any apparent neglect of courtesy, by pleading the unintermitting pressure of labor, and the numerous calls of our fellow-men for information, advice, or assistance, in lines of duty, with which they presume us to be acquainted.

The apology, implied in this remark, is drawn from us, that we may not seem inattentive to the civilities of many respectable persons, authors, editors, publishers, and others, both at home and abroad. It is still our endeavor to reply to all letters which appear to require an answer; although, as a substitute, many acknowledgments are made in these pages, which may sometimes be, in part, retrospective.—*Eds.*

SCIENCE.—FOREIGN.

Das Naturell die Krankheiten, das Arztthum und die Heilmittel der Urbewohner Brasiliens. Von Dr. K. Fr. Ph. v. Martius. München. From the Author.

Chemical Gazette, London. Conducted by Wm. Francis.

Verbreitung und Einfluſs des Mikroskopischen Lebens in Süd und Nord Amerika. Ein vortrag von C. G. Ehrenberg. Berlin, 1843. pp. 137, folio, with plates. From the Author.

Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königl. Preuss. Akademie der Wissenchaften zur Berlin, for 1840, '41, '42, '43, and to April inclusive of 1844. From Prof. Ehrenberg.

The Medals of Creation, or First Lessons in Geology and in the study of Organic Remains, by Gideon Algernon Mantell, LL. D.

In 2 vols. 12mo. London, Henry G. Bohm, Covent Gardens, 1844. From the Author.

On increasing the depth of Soils, by C. W. Johnson, Esq. London, 1840. pp. 72.

On Dinornis, an extinct genus of tridactyle Struthious birds, with descriptions of portions of the skeletons of six species which formerly existed in New Zealand. By Prof. Owen, M. D., F. R. S. From the Author.

Meteorologische Beobachtungen ans dem lehrbezirk der Kaiserlich Russischen Univerzitach Kasan. Auf Kosten der Universitach Herausgegeben, von Ernest Knob. Heft. 1, 1835–1836. Kasan, 1844.

Magnetical Advertisements, or divers pertinent observations and approved experiments concerning the nature and property of the loadstone, by William Barlowe. A new edition with notes, by William Sturgeon, lecturer to the Manchester Institute of Natural and Experimental Science. London, 1844. From the Author.

A Catechism of Agricultural Chemistry and Geology, by J. F. W. Johnston, M. A. Seventh edition. From the Author.

Elements of Agricultural Chemistry and Geology, by Prof. Johnston. Edinburgh and London. pp. 280. From the Author.

Lectures on Agricultural Chemistry and Geology, by Prof. Johnston. Edin. and Lond. Oct. 1844. pp. 2027. From the same.

Description of the Missourium Theristocaulodon, (Koch,) by Albert Koch; with a large lithograph. Dublin, 1843. From Author.

SCIENCE.—DOMESTIC.

The probable Influence of Icebergs upon Drift, by John L. Hayes. Read before the Association of American Geologists and Naturalists, May 4, 1843. Two copies, from the Author.

European agriculture and rural economy from personal observation, by Henry Colman. Vol. I, Part 1. From the Author.

Carpenter's Annual Medical Advertiser, Philad. 1844.

Illinois Medical and Surgical Journal, edited by James V. Z. Blaney, M. D. Chicago, Ill.

Boston Journal of Natural History, Vol. IV, No. 4. From the Society.

Observations on the external character and habits of the Troglodytes niger, Geoff., by Thomas S. Savage, M. D.; and on its organization, by Jeffries Wyman, M. D. Extracted from the Boston Journal of Natural History. From Dr. Savage.

Description of an African beetle, by Thaddeus William Harris. From Dr. Harris.

Papers on Practical Engineering, published by the Engineer Department for the use of the officers of the United States corps of engineers.

Treatise on Mineralogy, by Charles U. Shepard, M. D. Second edition. New Haven, 1844. From the Author.

A reply to a critique on Liebig's Animal Chemistry, by Lunsford P. Yandell, A. M. Louisville, 1843.

Transactions of the Society for the Promotion of Useful Arts in the State of New York, Vol. 3. Albany, 1844. From the Society, through H. O'Reilly, R. S.

Transactions of the Society for the Promotion of Agriculture, Arts, and Manufactures. From the Secretary.

New York State Agricultural Society for 1844, with the premium list and regulations of the cattle show. From the same.

Crania Ægyptiaca, or observations on Egyptian Ethnography, derived from anatomy, history, and monuments, by Samuel G. Morton, M. D. Philad. and London, 1844. From the Transactions of the Am. Phil. Soc., Vol. 9. From the Author.

Notes on Northern Africa, the Sahara and Jordan, by William B. Hodgson. New York, 1844. From the Author.

Gunn's Domestic Medicine, pp. 893, 8vo. New York, 1844. From the Author.

MISCELLANEOUS.—FOREIGN.

British, French, and German painting; being a reference to the grounds which render the proposed painting of the new houses of Parliament important as a public measure, by David Scott, Esq. 1841. pp. 85. From Mr. Dunlop.

Testimonials in favor of David Scott, R. S. A. 1843. London and Edinburgh. From Mr. Dunlop.

Reality of the gracious influence of the Holy Spirit, by the late John Jamieson, D. D., with a memoir of the Rev. Andrew Somerville. Glasgow, 1844. From J. Dunlop, Esq.

Booksellers' Catalogues.

Classical Museum, No. 111. London. J. W. Parker, West Strand.

MISCELLANEOUS.—DOMESTIC.

Oneóta, or the red race of America, by Henry R. Schoolcraft. New York, 1844.

Lecture on the late improvements in steam navigation, and the arts of naval warfare, with a brief notice of Ericson's caloric engine, by John O. Sargeant. New York and London, Wiley & Putnam. From the Author.

Hunt's Merchants' Magazine and Commercial Review, No. 61. July, 1844.

The twentieth annual report of the officers of the Retreat for the Insane at Hartford, 1844. From Mr. W. W. Turner.

The Dental Visitor, by J. W. Smith, M. D. Northampton, Mass. From J. Porter.

Report of the New Hampshire Asylum for the Insane, 1844.

Permanent Sabbath Documents, No. 1. Boston, 1844. From Mr. J. Edwards.

Sermon in behalf of the Foreign Evangelical Society, by Dr. W. B. Sprague. New York, 1843. From the Author.

Dr. Sprague's Address before the Society of Phi Beta Kappa in Yale College. New Haven, 1843.

Report of the American Temperance Union, 1844. N. York.

Report of the Trustees of the State Lunatic Asylum at Worcester, Mass., Dec. 1843. From Dr. Woodward.

Littell's Living Age, No. 1. Boston, E. Littell & Co. From the Publishers. 1844.

Memoir of Capt. Nathan Hale. New Haven, S. Babcock & Co.

Catalogue of Jefferson College. Canonsburgh, 1844.

Yale Literary Magazine, June 1844. From the Editors.

New Churchman extra. No. 11, 1844. Philad.

Mr. Seymour's Report of the Committee on Canals in Assembly, State of New York, April, 1844.

Proceedings of the Annual Convention of the Connecticut Medical Society, May, 1844. Norwich.

Sermon on the death of the Rev. J. Orr, by A. A. Baker. Boston, 1844.

The Annual Report of the Morrison Education Society. Macao, 1843. From Mr. Brown.

The Prairie Farmer for July, August, September.

Annual Report of the Martha Washington Temperance Society, New Haven, 1844.

Announcement of Jefferson Medical College. Philad. 1844.

Annual Circular of the New Hampshire Med. Depart. Dartmouth Coll. Hanover, 1844.

Speech of Gen. Chapman of Charles County, on the bill to provide for completing the Chesapeake and Ohio Canal from the revenues of the work. Annapolis, 1844.

The History of Illinois from its first discovery and settlement to the present time, by Henry Brown. New York, 1844. From the Author.

The Alpaca, its naturalization in the British Isles considered as a national benefit, and as an object of immediate utility, by William Walton. New York, 1845.

Speech of Samuel A. Foote, counsellor at law, New York, delivered at the mass meeting at Millstone, New Jersey, Aug. 7, 1844. Somerville. From Mr. Foot.

Nineteenth annual report of the Board of Managers of the Prison Discipline Society. Boston, 1844.

Dr. Dunglison's public discourse on Peter S. Du Ponceau, LL. D. Oct. 1844. Philad.

Rev. Mr. Barnes's sermon before the American Board of Commissioners for Foreign Missions. Philad. 1844.

Poland, Russia, and the policy of the latter towards the United States, by Major G. Tochman. Baltimore, 1844. From the Author.

Literary Record and Journal of the Linnæan Association of Pennsylvania College. Nos. 1 and 2, 1844.

Discourse pronounced July 30, 1844, before the Philomathesian Society in Middlebury College, by Wm. B. Sprague, D. D. Albany, 1844. From the Author.

Dr. Sprague's discourse on True Magnanimity. Albany, 1844.

An address before the Society of the Alumni of Harvard University on their anniversary, Aug. 27, 1844, by Daniel A. White. Cambridge, 1844. From the Author.

Statement of the facts and circumstances connected with the removal of the author from the Presidency of Kenyon College, by D. B. Douglass, LL. D. 1844.

Mr. Putnam's oration before the Phi Beta Kappa Society of Harvard University, Aug. 29, 1844. From Mr. Putnam.

Eighteenth annual report of the President and Directors of the Stockholders of the Baltimore and Ohio Rail Road Company. 1844.

Fifth annual report of the Morrison Education Society. Macao, 1843.

Introductory lecture to the course of Medical Chemistry in the Medical Department of Pennsylvania College, Philadelphia, by Washington L. Atlee, M. D. 1844. From the Author.

Remarks on a late editorial article in the Churchman, by Sam. H. Turner, M. D. New York, 1845.

Tenth annual Catalogue of the Pleasant Hill Academy, Hamilton County, Ohio. Aug. 1843. From F. G. Cary, Esq.

Third annual Catalogue of the Williston Seminary, East Hampton, Mass. Aug. 1844.

Catalogue of Brown University, 1844–5. Providence. From Dr. Caswell.

Catalogue of Harvard University, 1844–5. Cambridge, Mass. From Pres. Quincy. Also from Robt. G. Fisk and Prof. Beck.

Catalogue of Dartmouth College, 1844–5, Hanover, N. H. From Prof. Hubbard.

Annual announcement of the trustees of the Willoughby University of Lake Erie, Medical Department, for the course of lectures, 1844–45.

Prince's catalogue of Dahlias and other Flowers, Flushing, N. Y. 1844–5.

J. Munroe and Co.'s Catalogue of Books. Boston.

NEWSPAPERS.—DOMESTIC.

The Daily North American, Aug. 15, 1844. Nantucket Inquirer, July 13, 1844, with a notice of a meteor. Friend's Weekly Intelligencer, a series of numbers, Phila. Poughkeepsie Journal and Eagle, Aug. 31, with a notice of the State Agricultural Society. Clay Tribune, New York, June 22, with Mr. Clayton's speech. Colonization Society Herald, Phila. May, 1844. Dyott's Oracle of Health, July, 1844. The Tippecanoe Journal, Lafayette, May 27, 1844. Lexington Observer and Reporter, June 5, 1844, with the speech of C. M. Clay. Pittsburgh Morning Chronicle, July 26, 1844, with a letter to Cadwallader Evans, Esq. in relation to the explosion on board the Cleveland. Boston Daily Cultivator, April, 1844. Boston Chronicle, Sept. 1844, containing an account of Howe's Cave, Schoharie, N. Y. Boston Post, Oct. 8, 1844.

NEWSPAPERS.—FOREIGN.

The Non-Conformist, from Mr. Dunlop, London, May, 1844. The Edinburgh Weekly Chronicle, Aug. 10, 1844, from the same, containing an account of a celebration in memory of Burns. The Durham Advertiser, Friday, May 10, 1844, from J. Norton. Wilmer & Smith's European Times, Liverpool, Sept. 19, 1844.

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Art. I.—*Some Observations upon the Valley of the Jordan and the Dead Sea;* by John D. Sherwood, A. B. of New York.

If the biblical scholar has so much reason for the profoundest regret, when he reflects upon the long series of untrustworthy accounts with which the monkish travellers to Palestine have abused his earnest and patient enquiries after the sacred topography of that interesting country; surely the geologist and the explorer of natural history have equally strong grounds for complaint, if not of censure; since research there, besides the reward with which it must be attended in adding new and valuable facts to the great body of scientific knowledge, connects itself necessarily with the intelligent illustration of the Holy Text. Among the crowd of palmers, crusaders and general tourists who have written upon the Holy Land, scarcely half a dozen can be named who have given such a well-defined and systematic description of the appearance, even of its physical surface, as to convey any very precise notion of it to the general reader; while with the exception of the detached but truthful observations of Burckhardt, Seetzen, Hasselquist, Irby, Mangles and Dr. Robinson, the untravelled geologist wants altogether the materials for an intelligent arrangement of its geological phenomena, and the data from which to derive the organic changes to which, at an earlier period, the whole country has been subjected.

That the whole of Syria has been, even during the historical era, the theatre of important subterranean movements, in com-

mon with a large volcanic circle embracing Asia Minor, the countries lying about the sea of Aral, the Caspian and Black seas, the Thracian Chersonesus, Greece, the Ionian and Archipelagian islands, we have the general testimony of Pliny, Strabo, Josephus and other early historians: but their observations, limited to the effects of the more violent catastrophes in the destruction of man and his habitation, give us only partial and inferential information upon the amount and intensity of these internal movements and the topical changes they have wrought upon the surface. That the latter have not been inconsiderable, we are warranted in concluding, as well from the corresponding effects in the neighboring Mediterranean sea, where submarine volcanoes have caused from time to time the emergence of several permanent islands,* as in the signal marks which have been left in the mountain groups of Palestine itself, in the fissures gashing them and furnishing unequivocal evidence of intense paroxysmal violence; in the thermal springs found in the Lebanon chain and the vicinity of the Lake of Tiberias, and in the mineral products of volcanic origin, scattered in places where no earthquakes have occurred within the last ten centuries.

I propose here only to recall some of the leading geological features of a portion of Palestine, collecting from such reliable authorities as I have had access to, information to supply the deficiencies of my own notes made during a tour through the Holy Land in the months of April and May, 1843. My object is rather to furnish facts in aid of the speculations and investigations of those who have pursued such inquiries more thoroughly, than to follow out theories which an observation of those phenomena have suggested to my own mind.

1. *General outlines and configuration of Palestine.*

In its most flourishing state, under the extended rule of David and Solomon, Palestine embraced an extent of territory little larger than that covered by the counties that border upon both sides of the Hudson from New York to Albany; its ordinary limits were

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* Santorin, an island six miles long, from one to three in width, and eight hundred feet above the surface. Hiero, a small island, emerged 186 B. C. Micra Kameni in 1573. Nea Kameni, 1707.

See Lyell's "Principles of Geology," Vol. II, p. 137, for the effects of volcanic action in Greece, in submerging the cities of Helice and Bura; and elevating a mountain four thousand feet high near Moderi, Sicily.

still more circumscribed. On the west an inhospitable though not a rugged coast, running northeast and southwest, indented by small insecure bays, shows to the traveller skirting along it, five unimportant towns containing each from five to thirteen thousand inhabitants; three of which, Tyre, Sidon and Gaza, were once flourishing and busy seats of wealth and trade.* A vast prairie of sand presses upon its southern border, affording a safe hiding place for the restless tribes of Bedâwins, who issue from its pathless depths, and snatching cattle and grain from the cultivated land disappear again within their undiscoverable retreat. The swift little stream of the Jordan on the east, parts Palestine from the barren country of the once turbulent Moabites. The northern boundary, shifting with the fortunes of the Jewish and Israelitish monarchies, is fixed by no natural barriers. Hemmed within limits thus narrow, lies the ancient inheritance of the Jews, a territory not inconsiderable if contrasted with the earlier Greek states, Sicyon, Agamemnon's monarchy, Corinth, Megara, Eleusis, &c. in several of which a modern medical practitioner might without difficulty pursue a practice at one time; but which Americans would deem to be a small territory for a state. Such however was the fertility of the soil and the genial character of the climate, exempting the inhabitants from the imperious wants incident to our colder latitudes, namely, substantial houses, clothing and diet, that Palestine in David's time contained six millions of people. It now numbers about one million five hundred thousand, comprising both the native and Christian population; a difference which can be in some measure accounted for by the present neglect of agriculture, the insecurity of property, and the rapacious exactions of the Pashas sent from Constantinople. I am not prepared to say that the present resources of Palestine, if sagaciously developed, could not maintain the ancient population; I only allude to its present diminished physical capacity, to make a suggestion, collateral to others which will be subsequently introduced, viz. that changes, some remote, others recent, depending upon a variety of disturbing causes, have both absolutely and relatively

* Although the Mediterranean has no tide, the great prevalence of west and southwest winds, creating a strong current in those directions, has sensibly changed the sea-coast of Palestine. The roadsteads of Beyrût, Sidon, Tyre, Jaffa and Acre, now afford very unsafe anchorage, even for the diminutive coasting craft that frequent them.

affected the present surface of Palestine. The vine, so important among the ancient productions of Palestine, has almost wholly disappeared; the olive lingers only in occasional patches, and has deserted many of its old localities; the pomegranate is rarely seen. The Jordan too has diminished its volume, changed its habits and in some places altered its direction; while the remarkable valley through which it runs, has, it must be inferred, undergone a thorough and radical change. I must again repeat, that the want of any series of recorded geological observations on the country, leaves us to make out these conjectures from the phenomena that now present themselves, whose deviation from those preceding them, can be satisfactorily determined only by future careful observations.

Palestine is strongly marked by mountain ranges. The chief line, the great back-bone of the country, in the New Testament called "the hill country of Judea," starts from the desert, runs north and south through the whole length of Judea and Samaria, then bending in a northwesterly direction terminates at the sea-coast in the steep cliffs of the promontory of Mount Carmel, eight miles south of Acre. A few insulated abrupt hills, Mount Gilboa, Little Hermon and Mount Tabor, sentinels upon the northern skirt of the great plain of Esdraelon, occupy the southern part of Galilee. The Lebanon chain commences a little northward of these detached hills, in the low swells around Nazareth, rising to a considerable elevation as they stretch forward into the volcanic Safid chain, until they are lost in the stern precipitous ridges of Lebanon. All of these mountains are of limestone formation; those of the southern or central chain are steep ridges of a friable rock, in mineral character approaching chalk, and having been manifestly subjected to a very high temperature. The Lebanon range is composed of compacter limestone, in which the gullies worn by the autumnal rains present a more direct and uniform channel. The strata are horizontal or nearly so, appearing frequently through extensive districts in long parallel ledges of one uniform breadth, as if placed artificially one upon the other. The chief central ridge of mountains, rising to a height of one thousand to one thousand nine hundred feet* is covered by a growth of aromatic

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* The summit of the Mount of Olives is twenty-five hundred feet above the level of the sea.

shrubs, the oleander, arbutus, wild rose, &c. pushed out from the crevices of the mountain, or by an occasional dwarf olive, maintaining a doubtful and contested existence upon the thin soil. This chain seems at a distance to be one single unsupported ridge, with a summit slightly waving; but upon approaching it the composing ridges separate from the mass, those of lower elevation lying in front of the superior one, all uniting in curvilinear bases and rising in distinct parallel ranges. This central chain determines the configuration of the greater part of Palestine; giving the shape to the plains that lie in between the spurs that it sends off, and the direction to the streams that are fed from its bosom, and fall on the one side into the Mediterranean, and upon the other into the Dead Sea, the river Jordan, the lakes of Tiberias and El Hûlil. Between its base and the Mediterranean, stretches a vast alluvial, unfenced plain of pasture and wheat land, whose verdant knolls are everywhere covered by small Arab villages of stone, in which, gathered at once for society and protection, almost the whole fixed population are to be found. The rounded pebble stones strewed over this plain, and the bones of marine animals, fish and testacea, mingled everywhere with the soil, indicate the subaqueous character of its formation. No observations, so far as I am informed, have ever been made to determine the nature or order of the depositions which have converted the former bed of the sea into dry land; but the uniform undulations of surface which characterize this plain, show that its bed was formed in an open flowing sea, exposed to the influence of the currents; while the perfectly horizontal level of the great plain Esdraelon indicates that the sediment was thrown down in an archipelago, the present insulated mountains of Tabor, Hermon, &c. forming the chief islands, and favoring the quiet process of deposition which finally, by gradual accessions, raised the bottom to the surface.

2. *The Eastern part of Palestine.*

I have spoken of the great western plain intervening between the mountains and the Mediterranean; eastward of these mountains, however, lies a tract which exhibits every element of sterility and desolation. This entire district, comprised between a line drawn ten miles east of Jerusalem due north and south, and the Arabian mountains, which form the eastern boundary of the Ghor, as the Syrian Arabs term the Jordan valley,—a tract averaging eighteen miles in breadth by one hundred in length, and

embracing at least one third of the surface of Palestine, is made up of a series of naked limestone hills, springing from broad bases, divided from each other by little gravelly gullies, and running upwards into sharp acuminations: those on the north of this region terminating in a conical form, while those southward, i. e. west of the Dead Sea, take a wedge-like shape: the valleys between them narrowing downwards as the hills sharpen upwards. Should a quantity of hatchets of the usual figure be placed with the edges upwards, and the nearest horizontal and parallel lines of the several backs touching each other, they would represent the hills, while other hatchets put between them with their edges downwards would represent the valleys. There is a rapid declination in the height of these hills eastward, between the Jordan valley and the central chain; a general subsidence, referable I believe to the same agencies which, prolonged through indefinite periods, have lowered the bed of the Jordan; the intense igneous action of their movements affecting the whole adjacent region. The sudden rents and jagged perpendicular ravines that break down here and there, forming frightful gorges bounded by precipitous walls, may have been opened by subsequent volcanic movements, to which, it is well known, that the whole country has been frequently and severely subjected.

(1.) With the exception of a few olives and pomegranates around Jericho, a small village in the Jordan valley, and a few patches of green grass and shrubs scattered here and there throughout the tract, and along the western shore of the Dead Sea, there is *scarcely a tree or shrub or blade of grass in all this district.* It would seem as though the curse which overwhelmed the cities of the plain, was still burning over its arid and scathed surface.

(2.) A *fixed population* is, therefore, limited to Jericho and the small store-house village of the Tamamaârah Bedâwins. The country however, is not wholly uninhabited. The plundering and lawless tribes of Tamamaârah, Rashâideh, Damâirah, &c. roam over this wild country, openly defying the Pasha of Jerusalem, and robbing either directly or indirectly all who pass through; directly by seizing all, indirectly by forcing travellers and caravans to take them as an escort against themselves, who are the robbers. With all his bandit qualities however, let me here remark, that the untamable Bedâwin stands in favorable contrast with the crushed and degraded Fellâh of Egypt, and the Arab cultivator of the more fertile districts of Palestine.

3. *The Jordan Valley.*

In the eastern portion of the grassless region I have described, and about sixteen miles eastward of a line drawn north and south through Jerusalem, runs the deep valley of the Jordan. Beginning at the upper end of lake Banias and stretching southwards, enclosing the Sea of Tiberias, a lake about six miles wide, and filling the breadth of the valley, it continues in the same southerly direction and with nearly the same breadth, about seventy miles, where it is again occupied by the Dead Sea, distant from whose southern end ten miles, it comes to an abrupt termination.

(1.) This valley is very much depressed below the level of the Mediterranean,* a depression to which its excessive heat had drawn the attention of travellers; but this temperature was in part accounted for by the position of the Ghor, enclosed between high and almost perpendicular limestone mountains, reflecting the sun from their white, glaring sides, into the valley below. Approximate results from barometrical measurement gave a depression from three hundred to six hundred feet; Dr. Robinson has adopted the latter. But a minute and careful triangular survey, by a corps of English engineers, of the whole country lying between the Jordan valley and the Mediterranean, has recently settled *the depression of that valley below that sea, at one thousand three hundred and eighty feet;* and consequently *one thousand four hundred and ten feet below the level of the Red Sea.*

(2.) The sides of the valley are bounded by steep hills of limestone, those on the west from eight hundred to one thousand four hundred feet high, those on the east from four hundred to eight hundred feet higher. They are cleft by valleys, along whose bottoms rush, during the rainy season, furious little torrents into the great arterial current of the Jordan. This river, which gives its name to the valley, and divides it into two nearly equal parts, varies in width from eighty to one hundred and fifty feet, pouring between its sedgy banks an unfailing supply of fresh water into the Dead Sea.

4. *The Dead Sea.*

This mysterious lake, concerning which so many early, extravagant accounts have been published, has never yet been satisfactorily explored. The rash attempt of Costigan the Irishman in 1835,

* See Vol. XLII, p. 214, of this Journal.

who caused a boat to be transported from the Mediterranean across the country and launched—his enterprise with a sole Arab servant—his three days' exploration—his death from exposure and want of fresh water, before he could make known his discoveries, are pathetically told by Stephens. From what I could learn however, at Jerusalem, Costigan was as destitute of scientific and instrumental knowledge as he proved to be of ordinary prudence; and had he lived would probably have revealed facts of but little value. That the exhalations from the lake are too pestiferous to admit of the necessary exposure for its survey, will scarcely be maintained;* and while the other obstacles arising from the hostile character of the Bedâwins, the difficulty of transporting a boat to the shore, the want of provisions, water, &c. are too slight to be entertained by any enterprising traveller, it is to be hoped that an exploration, where important discoveries are sure to follow the experiment, will not long be deferred. At present therefore, our knowledge is made up of partial observations and experiments, the most important of which I shall here detail, in order to embody into one view, the leading features of this extraordinary region.

(1.) The lake is about forty miles long and from six to eight miles wide; a broad peninsula, composed of slate, marl, earth and other matter, broken down from the rocks in the rear or gained apparently from a former overflow of the waters of the lake, projects from the eastern shore on the south and contracts the breadth of the sea to within two miles. South of this the water is very shallow; so that in midsummer, when in consequence of evaporation the body of the lake falls from twelve to fifteen feet, this end is left a marsh.

(2.) The *eastern* shore consists of almost perpendicular cliffs of limestone rock, from sixteen hundred to twenty-five hundred feet high, running up in ragged splintered points, or advancing out from the main line, standing like massive bastions propping up the gigantic wall in the rear. This range, following nearly a north and south direction, recedes from the southern coast and thus allows access to the peninsula. The *west* shore, from fourteen hundred to two thousand feet high, is more broken than the eastern; but presents several strikingly bold cliffs, beetling over the water and throwing upon it their deep shadows.

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* It was formerly believed that no birds could, or did fly over the lake, but this is not true. The same fact is falsely asserted of Lake Avernus, near Naples.

At the southwest corner of the lake occurs a large promontory of fossil salt, overlaid with marl and earth, down which little rills constantly trickling, give to the lake its highly saline character. A narrow shelf of land intervenes between the water and the base of the western mountains, cut off in three points by the advanced cliffs. On the south, the valley again begins, or rather is prolonged southwards by a marsh, which at length gives place to a bed of an indurated nitrous character, mixed with marl, pieces of red sandstone and porphyry.

The northern shore, which I visited, is a sand beach, sloping gently down from the water's edge; a line of sand running back (at that time about two feet) covered with weeds and drift-wood, indicating the high-water mark. The view from this shore down the lake, sunk between its precipitous walls, is one of appalling sublimity. There it lies motionless and dark, with no voice, no pulse of life around or within it. No fish inhales its waters, no snail crawls along its shores, no trace of aught, human or animate, is any where to be seen.

In the course of a wide range of travel through the greater part of Europe, a portion of Africa and Asia, and my own country, I have witnessed nothing whether of the physical or moral sublime, so sternly impressive. The wildest districts of Switzerland, Scotland and the Tyrol, and the sternest features of northern Greece and Asia Minor, are tame when compared with the Dead Sea.

(3.) The water is of a dull green color, though highly transparent, so that the eye traces the pebbles which cover the bottom, and are very various in color, for a great distance. Among them those of fetid limestone predominate; they are bituminous, and emit a strong odor when rubbed against a woolen coat. In some cases the bitumen has invested other stones, and formed a coating so tenacious that it is impossible to detach it mechanically. As no springs of petroleum or pitch have been discovered along the shore, we can only infer the conditions under which the bitumen is found at the bottom by its appearance when thrown ashore. Judging from the fracture and the vitreous texture throughout, we are warranted in concluding that it first appears in a fluid state like tar, and afterwards cools down under the pressure of the water.

(4.) There is no outlet to the sea: so that the whole body of water brought into it by the Jordan, the six streams upon the east

and four upon the west, must go off by evaporation, by some subterranean channel, or more probably by both united. *The precipitation of salt* to the bottom during the summer months, in consequence of the great evaporation, must we presume be considerable.

(5.) *Specific gravity.* The water of the Dead Sea has been frequently analyzed by European chemists, the varying results of whose experiments—a difference easily explicable by those who understand the disturbing influences affecting the lake—have only increased the necessity of multiplied examinations, in order to furnish an intelligible approximation to a correct average.

For the subjoined analysis of a portion taken from the lake at the time of my visit, April 18, 1843, I am indebted to the kindness of Mr. B. Silliman, Jr.*

The portion here analyzed by Mr. Silliman, Jr., is, I believe, the first ever experimented upon, this side of the Atlantic. It was sealed up at the time of taking it, and so kept until my arrival at home in November last, when immediately after opening, it was again hermetically closed. I am thus particular in regard to the time, since the season, owing to the more rapid evapora-

* The water which Mr. Sherwood brought from the Dead Sea, and of which I received a portion from him, had a specific gravity of 1·1509 on several trials; being less than the least weight named in the four analyses quoted below, viz. Dr. Apjohn's, 1·153. It was neutral, having no effect on litmus, or Georgina leaves. On boiling for some time, no insoluble deposit appeared, and no escape of gaseous matter; evaporated to dryness at 212° to 220°, it re-dissolved entirely in pure water. Hence I infer the absence of *carbonic acid* and of *bicarbonates.*

Paper prepared with acetate of lead remained unchanged, whence, as well as from the foregoing, I infer the absence of *sulphuretted hydrogen. Ammonia, alumina, phosphoric acid*, and *iodine*, were sought for in vain. A current of chlorine gas passed through the water soon developed a fine brownish red color in the fluid; *ether* agitated with it took up all the coloring matter, and a solution of caustic potash at once made it disappear from the ether. This was good evidence of the presence of *bromine.*

Dr. Daubeny (see Report on Mineral and Thermal Waters in the 6th Report of the British Association, p. 47) has remarked in speaking of the constitution of mineral waters—" that as the salts existing in a spring need not be the same with those obtained on evaporation; and as salts viewed as incompatible may co-exist in a state of weak solution, the analysis of a mineral water consists in nothing more than in determining the nature and amount of the several acids and bases which it contains. But Berzelius has further contended, (in his analysis of the Carlsbad water, Ann. de Chim. xxviii,) that every thing beyond this which the chemical analysis professes to give, is a matter of hypothesis. He also says, and apparently with much justice, that consistently with the views of Berthollet on the influence of the mass, we ought to suppose as many salts to exist in a mineral water as can be

tion during the summer months, becomes an essential consideration in the statement both of the specific gravity and component elements of the water. At that time the rainy season, or "latter rain," had just passed; the Jordan and the streams on the east, south and west, had discharged themselves into the lake, thus diluting, by this accession of fresh water, the previous body of water in the lake.

The specimen analyzed, was taken from the northwest angle of the sea, about three miles from the mouth of the Jordan, a consideration scarcely less important than the former, when it is recollected that the Jordan alone is supposed to discharge, on an average, daily, about six millions five hundred thousand tons of water into the Sea, a discharge that must sensibly affect the quality of the water for a considerable distance around the embouchure.

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formed out of the constituents present, whilst the proportion in which these salts exist is a point which we cannot obtain data for calculating, until we are able to estimate numerically the relative force of affinity subsisting between the ingredients. According therefore to the received views on this subject, the chemist ought in strictness barely to set down, as the results of his analysis, the respective weights of the acids and bases present."

With this view of the subject, I have not endeavored to reconstruct the water of the Dead Sea from my analysis, but have only given the several weights obtained.

1st. Acids.—*Chlorine:* This was precipitated by nitrate of silver, and the bromine of course was thrown down by the same operation. After drying the mixed chloride and bromide of silver, it was fused in a porcelain crucible of known weight, and the weight of the fused mass obtained. To estimate them separately, as much of the mixture as could be removed conveniently from the crucible on warming it over a lamp, was introduced into a tube of hard glass and weighed. The tube was then connected with an apparatus by means of which dry *chlorine* was passed over the assay while heated to redness by a lamp. The chlorine thus combined with the silver before in union with the *bromine*, and the resulting loss of weight was ascertained by the balance. Estimated in this way, 100 parts of the water yielded

Chlorine, ...	10·290
Bromine, ...	0·684

Sulphuric acid was detected by hydrochlorate of baryta, but in quantity too small to be estimated.

2d. Bases.—*Lime* was thrown down by oxalic acid, converted into sulphate after ignition, and weighed 1·424. Magnesia was separated from the alkalies by means of the process recommended by Berzelius, with oxide of mercury. The magnesia weighed 2·355 per cent.

The alkaline chlorides were evaporated to dryness, and the weight calculated from the known constitution of the chlorides. The soda contained only a trace of potash, and weighed 3·008 per cent.

Recapitulation.—The constitution of the water of the Dead Sea, therefore, by this analysis, is as follows:

It is mainly owing to an inattention to these seriously modifying causes, that the astonishing difference in the weight and relative proportion of soluble salts, found by Gay Lussac and others, in the portions analyzed by them, is chiefly attributable. The water analyzed by Dr. Apjohn, and having a less specific gravity than the others, was dipped up about a mile from the Jordan, immediately after the heavy autumnal rains. It will be noticed also, that in that case the amount of salts, which, supposed in a dry state, are usually equal to one fourth the weight of the water containing them, is for the same reason very much reduced.

The density of the water was very strikingly illustrated upon our bathing in the sea. We were a party of thirty-five; nine of whom bathed. Two had never before been able to swim; *there* however, they floated like corks. Indeed, had the water been frozen to the bottom, it could not have borne us up more effec-

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Water,	82 139
Chlorine,	10 290
Bromine,	0·684
Sulphuric acid,	trace
Soda and trace of potash,	3 008
Magnesia,	2·355
Lime,	1·424
	99·900

B. SILLIMAN, Jr.

Yale College Laboratory, Jan. 6, 1845.

In order to afford a comparison with a few of the former experiments, Mr. Sherwood adds, from Robinson's admirable "Researches on Palestine, (Vol. II, p. 348,) the results of four of the most accurate, made at different times, viz.

	By Dr. Marcet of London, 1807.	Gay Lussac, Paris, 1818.	Prof. Gmelin, Tubingen, 1826.	Dr. Apjohn, Dublin, 1839.
Specific gravity, distilled water taken as a standard at 1·000,	1·211	1·228	1·212	1·153
Muriate of lime, or Chloride of calcium,	3·920	3·98	3·2141	2·438
" magnesium,	10·246	15·31	11·7734	7·370
" sodium,	10 360	6·95	7·0777	7·839
Sulphate of lime,	0·054	. . .	0·0527	0·075
Bromide of magnesium,	. . .	. . .	0·4393	0·201
Chloride of potassium,	. . .	. . .	0·2117	0.005
" aluminium,	. . .	. . .	0·0896	. . .
" ammonium,	. . .	. . .	0·0075	. . .
	24·580	26·24	24·5398	18·780
Water,	75·420	73·76	75·4602	81·220
	100.	100·	100·	100.

tually. I lay upon the surface with both feet and both hands in the air. I walked out into the lake, sinking only to the neck. In a horizontal position it was impossible to sink or to force one's self down. One of our party plunged in with his eyes open; but emerged immediately with a scream, his eye-balls glowing like coals of fire, smarting and watering for hours afterwards. On coming out a pricking sensation was felt upon the skin; small globules of oil, like naphtha, stood over us; while our heads and beards immediately whitened in the sun, covered by minute crystallizations of salt.

I shall here close my remarks upon the Dead Sea, and shall finish this paper with

5. *Some observations upon the changes which the whole surface of Eastern Palestine has undergone and is now undergoing.*

The phenomena already described might be made the basis for wide and interesting speculations; I shall however limit myself to the suggestion of only a few. The connection of the preceding facts with the various theories respecting the existence of the Dead Sea previous to the destruction of the cities of the plain, and with the manner of their destruction, is manifest. The Dead Sea, which is supposed to cover those cities, is a continuation of the Jordan valley—a valley as we have seen stretching ten miles south of the southern end of that sea, where a line of cliffs makes an abrupt offset to the valley (El Arâbah) coming down from the south. This is according to Dr. Robinson's late discoveries;* as it was formerly supposed that the Jordan valley prolonged itself to the eastern arm of the Red Sea—that the Jordan River issuing from the southern end of the Dead Sea, intersected that valley throughout its whole extent—that the destruction of Sodom and Gomorrah, 1898 B. C. broke up the plain—that the waters settled into a lake, the present Dead Sea, and consequently, that all the phenomena there observed, must be explained in accordance with these hypotheses. But the break in the valley of the Jordan, and the fact that the Jordan does not issue from the Dead Sea, but on the contrary that the stream south of that sea runs *northward* into it, show that there has not been, since a very remote era at least, any connection between the waters of the Dead and Red Seas, and that the whole Jordan valley has undergone an organic change, an entire depression.

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* See Vols. II and III, *passim.*

When did this change occur? Is it coeval, as Dr. Robinson seems to think, with the formation of the present crust of the earth; or is it contemporaneous with the destruction of the cities of the plain? We believe that it is not assignable to either of these periods; but is the result of causes operating slowly through long spaces, or as we may say through all time, or continually—causes which sometimes have made themselves felt there with greater intensity than at others, but which are constant even in their apparent fluctuations.

The volcanic character of the whole region has already been adverted to. The thermal and mineral springs that occur along the shores of the Dead Sea, the Lake of Tiberias,* and in the vicinity of Safed—the hill of fossil salt at the southwest end of the Dead Sea—the nitrous crust covering the bed of the Jordan valley north and south of the sea, the pieces of sulphur found at various places in its vicinity, the bitumen exuding upon its bottom, and the arid, burnt soil of the contiguous country, all bear evidence to the igneous nature of the agencies that have produced them—agencies which we cannot believe have confined their action to the fruitless production of these marks, but have left the impress of their destroying and upheaving force upon the whole region. Earthquakes also, shaking this district from time to time, opening seams, giving passage to new streams, or disclosing hot springs, testify that this subterranean power is still active. Josephus makes mention of one in the time of Herod which destroyed ten thousand people.† In 1759 a violent convulsion shook down part of the walls of Safed: it lasted three months, and destroyed three thousand people. But the severest shock was felt in 1837, which prostrated the whole town of Tiberias, burying many of the inhabitants beneath the ruins, causing vast rents in the adjacent hills, and displacing broad areas of land. This movement was felt throughout the whole Jordan valley, and followed the linear direction of the mountains which bound it.

Had we a series of records made by scientific observers of the time of the occurrence of all the violent catastrophes that have happened in this region, but more particularly of the new phenomena that have occurred in the intervals of great agitation, un-

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* At the baths of Emmaus, on the west shore of this lake, the water has a temperature of 150° F. and is highly sulphureous.

† Liber xv, § 2.

accompanied by the more striking exhibitions, we should have some data by which to measure the amount of change that this force, irregularly active but uniformly modifying in its effects, has wrought upon the configuration of the mountains, their absolute and relative elevation above the bed of the valley, and the changes in the water-courses that flow down them.

Even then however, we should only arrive at an approximate result of its agency; since it would be impossible to estimate the relative change of level over so wide a space, especially as there is no well-defined line, like a sea-coast, from which we can derive the amount of the movement.

We are entitled however, to infer from analogous effects elsewhere observed, accompanied by similar phenomena, that this process of upheaval, with all the changes incident to it, has been going on for centuries in the great region east of Jerusalem; sometimes actively, when the internal fire has made itself visible at the surface, and again slowly during long periods of comparative repose, when the disturbing agent has shifted the struggle to other points. We have an example of the elevatory and depressing character of these subterranean movements in the country adjacent to the Caspian, and in the Caspian itself, where the island of Adak, once considerably elevated above the water, has now almost disappeared. Among the Caucasian chain great subsidences and upheavals have been noticed to succeed earthquakes. The Mediterranean has witnessed the appearance of new islands, lifted up from the bottom, violently or gradually, in almost every part of it. The Santorin group has already been mentioned. The island of Merita, near Sicily, arose in 1831, and afterwards disappeared; Messina has been the frequent theatre of volcanic action, while the opposite coast of Calabria affords abundant testimony of the modifying and transporting power of volcanic action, in the emergence of new points of land above the surface of the water, the lowering of others, the formation of new lakes in the place of dry land, the elevation of new ridges in some places, and the appearance of wide fissures in others.*

But Chili and Sweden furnish upon a broad scale the most incontestable proof of the power of internal heat to elevate vast areas of land. In 1822 the whole coast of Chili, from the shore

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* Lyell's Geology, Vol. II, pp. 324—352.

to the foot of the Andes, was permanently upheaved. "The rise upon the coast, was from two to four feet; at the distance of a mile inland, it must have been from five to six feet. The area over which this permanent alteration of level extended, may have been equal to one hundred thousand square miles."*

These changes and oscillations have been remarked elsewhere, because the coast lines have afforded a ready means of determining the rise or depression of the land; while the difficulty of ascertaining the alteration in the level of *the interior* has been acknowledged by all who have turned their investigations to these phenomena. How much then is this difficulty increased in a country where no fixed population are found, and consequently none of the facilities for observation exist with which such a residence is attended; the disturbing causes act there only upon an uncultivated surface. There are no houses to be overthrown; no towns whose rent walls are tottering memorials of some sudden paroxysm, or whose departure from some point which had not partaken of the movement, has been observed and recorded.

One of these violent catastrophes *has been* recorded, the overthrow of Sodom and Gomorrah, an event miraculous in time, and penal in its design; but effected by causes and means by which they were surrounded. Whether these cities were destroyed by the inflammation of the bituminous matter *upon* which they were built, or *with* which they were constructed, or whether a sudden volcanic eruption, opening wide fissures through which red-hot lava, "the rain of fire" poured, engulphing and destroying the guilty cities, we cannot now determine. The account was written, not to gratify curiosity, but to indicate to all times a sense of the Divine justice. Perfectly compatible however with that lesson, is the supposition that it was brought about by natural agencies. Nor is it the less signal because phenomena, similar in their nature and produced by causes operating constantly, though with intermitted vigor, have since appeared and may be still expected to occur.

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* Journal of Science, Vol. XVII, pp. 40–45.

ART. II.—*On the Crystals which occur spontaneously formed in the tissues of Plants;* by J. W. BAILEY, Prof. Chem. U. S. Military Academy,—(with a plate.)

(Read before the Association of American Geologists and Naturalists at Albany, April, 1843.)

PART I.

If the objects of this society were less extensive than they are, and if it were an Association for the improvement of geological science alone, instead of embracing natural history in general, I should still feel that no apology would be necessary for asking your attention to a paper on the crystalline matter of plants.

Examinations of the nature of the saline matters which occur spontaneously crystallized in the cells of plants, are so directly connected with the subjects of agricultural chemistry and geology, which have already engaged the attention of this society; that, independent of the interest which this subject may present to the botanist, chemist, and crystallographer, it is, I think, not wholly unworthy the attention of the geologist.

It is not my intention to consume the time of the society, by relating what has already been discovered upon this subject, especially as full information in regard to it may be found in a very able paper, by E. J. Quekett, Esq. of London, which is appended to the second edition of Lindley's Botany. My present object is to give a statement of my own observations and experiments, and I hope that I shall be able to present some new facts, and perhaps to place some well known ones, in a new, if not a stronger light.

My investigations of the subject are far from complete; numerous facts, requiring further observations and experiments, have presented themselves; and it is my hope that I shall be able in a second part of this paper, to supply some of the deficiencies left in this; and to give the results of researches, which are as yet in too incomplete a state to be placed before you.

In the present part of this memoir, I shall confine my attention chiefly to the crystals in Dicotyledonous plants.

My attention was directed to this subject by an accidental circumstance; I noticed one day, upon my hearth, the white ashes of a hickory cinder, which appeared to retain the pores and other

organic structure of the wood. Remembering the assertion of Rev. J. B. Reade, that plants when burned, left a skeleton of saline matter, retaining the forms of the cells, and other organs, I wished to verify the statement in this case by examining the ashes, which seemed to be in a very favorable state for observation. I accordingly melted some thickened Canada balsam, upon a piece of glass, and touched it very gently to the ashes; a portion adhered, and by blowing off what had not touched the balsam, I obtained, as it were, a longitudinal section of the ashes, in which the particles retained the relative position in which they were left by the combustion of the wood. As the balsam hardened in cooling, the section was left in a state of great transparency, and firmly set, so that it could be kept for years. On submitting the ashes thus prepared to microscopic examination, my attention was immediately arrested by long rows of brownish polygonal bodies.

Similar observations were then made on the ashes of the oak. Polygonal bodies were found in great abundance, but smaller than in the hickory, and presenting considerable diversity of form. The ashes of many other trees presented similar polygonal bodies, and they were, indeed, found to constitute a large proportion of the insoluble matter in the ashes of most dicotyledonous trees, whether indigenous or exotic.

It became then, a matter of considerable interest to determine the nature of these bodies, and to ascertain whether they were really, as they appeared to be, the remains of crystals, or merely saline matter, to which a polygonal form had been given by deposition in the polyhedral cells of the wood.

The same plant which first drew my attention to the subject, solved the enigma. On looking at the bark of any species of hickory* when exposed to the direct rays of the sun, numerous crystalline particles were distinctly seen, and I found no difficulty in examining them, *in situ*, in thin layers of the liber or in sections of the bark or wood. But they were more satisfactorily seen when completely isolated, which was easily effected by scraping a little of the bark above a plate of glass, and then blowing off the woody particles, after the crystals had been made to adhere by slightly moistening them with the breath. The mi-

* Carya alba, C. porcina, &c.

croscope then showed these glimmering points to be beautiful crystals, of the forms represented in figures 1, 2, 10, and 11, some being single as in figure 1, and great numbers compound or twins as in figure 2 *b*.

When these crystals were heated they became opaque, and if then placed in water or Canada balsam, they perfectly resembled the polygonal bodies found in the ashes of wood, so that no doubt was left as to the origin of the bodies in question.

The general form of the crystals which I had thus detected in the bark and wood of hickory, so much resembled the figures given by Raspail* of crystals found by him in *Iris florentina*, that I had but little doubt that they were identical, but a slight examination showed that either Raspail had made an error, or the crystals of the Iris and hickory must be different, as their forms appeared incompatible, belonging to entirely different crystalline systems. Raspail's figures represent modifications of right square prisms, while the forms in hickory are evidently monoclinate,† being derived from a right rhomboidal or oblique rhombic prism. Examinations of the crystals in *Iris florentina*, and various other Iridaceous plants, such as *Gladiolus psittacina*, *Crocus vernus*, &c., convinced me of their identity in form with those found in hickory, and that Raspail's representations of the terminal modifications are incorrect, and his measurement of the plane angles does not agree exactly with mine. Those which he measured, he states, gave 62° and 149°, while both in the hickory and the Iris the same angles as measured by me, gave 60° and 150°. He appears also to have overlooked the fact, that the plane angles which are diagonally opposite on the same face are not equal, being in this case 70° and 145°. (See figure 10.)

Having mentioned to my friend Dr. Torrey the occurrence of these crystals in hickory, he kindly furnished me specimens of a South American bark, said to be used as a substitute for soap, (*Quillaja saponaria?*) which was filled with crystals precisely similar to those found in hickory, and which I think he said he had analyzed and found to be oxalate of lime. Raspail also gives this as the composition of the crystals in Iris. The account of the experiments which I made on these and other crystals, to determine their composition, I shall give further on.

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* Nouveau Systeme de Chimie Organique, Plate VIII, figs. 7, 8, and 10.
† Hemi-prismatic of Mohs.

The detection of such vast quantities of crystals in every species of hickory, and the indications of similar phenomena in other trees, presented by their remains in ashes, led me to examine many other trees. I soon found that the bark of every species of oak, birch, chestnut, poplar, elm, locust, and all the common fruit trees, as the apple, pear, cherry, plum, &c., besides a vast number of others, were literally crowded with crystals.

The thin layers of the liber of the poplar, locust, chestnut, &c. when moistened and examined by the microscope, presented a most beautiful mosaic work of crystals. Each of the cells of the liber shewed either single or twin crystals, disposed as seen in figure 5, which was drawn from the liber of *Populus grandidentata*, but which will serve to show the form and arrangement of the crystals in all the trees just mentioned, as well as in many others.*

Even when it is difficult to see the crystals *in situ*, owing to the presence of globules of starch and chlorophylle, or to the density of the tissues, they may yet, in general, be found by scraping the wood or bark into water, in a watch glass. When the woody particles are picked out, the residue will generally show abundance of crystalline matter. By this method crystals may be obtained in an isolated state, even from such dense woods as mahogany, heart of oak and lignum-vitæ, and even when this process does not give good results, the presence of the crystals in great quantity may be demonstrated by placing a portion of the ashes in Canada balsam. They may be readily found in the powdery matter of worm-eaten wood; in saw-dust also; and abundantly in the finer portions of the ground dye-stuffs of commerce, such as logwood, fustic, quercitron, Brazil wood, sandal wood, camwood, &c.

The examination of leaves also gave very beautiful results. By slowly burning the leaf until the ashes became perfectly white, the form of the leaf was usually retained, and when encased with Canada balsam showed beautifully the saline skeleton of the leaf. In the full grown leaves of most trees, it was found by this method that rows of crystals accompany every ramification of the vascular bundles, so that even the minutest vein of the leaf is represented in the ashes by its row of crystalline par-

* The appearance by polarized light is very beautiful, presenting an elegant mosaic work of rubies and emeralds.

ticles. In very young leaves these crystals were only found along the midrib and some of the principal veins. In the leaves of other plants, the crystals were found by this method to be scattered in stellate bunches all through the parenchyma of the leaf. The ashes of the leaves of *Nelumbium luteum*, *Salisburia adiantifolia*, *Acalypha virginica*, and many others, gave most beautiful displays of these groups.

Having found by the above mentioned experiments that crystalline matter was present in vegetable tissues in much greater abundance than is generally supposed, I next endeavored to ascertain if the crystals in different plants had any relation in form and composition. I soon found that in a very great number of dicotyledonous plants, the crystals could all be referred to modifications of the form represented in fig. 4. The most common form is shown in figures 5, 6, 7, and 8, which show different positions of similar crystals. This form appears to be a rhombic prism oblique from an acute edge, and with the acute edges replaced by the planes $\breve{e}$, $\breve{e}$.* This form I shall refer to as form A. With the above, the unmodified prism, fig. 10, sometimes occurs, as in *Rosa rubiginosa*, *Broussonetia*, &c.

Compound or twin crystals, derived from the same primary, are also very frequent. Fig. 9 shows a common form, in which composition has taken place parallel to the plane P.

Crystals belonging to form A were found by me abundantly in more than one hundred species of plants, belonging to upwards of thirty different families, which families include the great majority of dicotyledonous trees and shrubs, besides many herbaceous plants.

The extent to which this form occurs will be understood when I state that it is found *abundantly* in every species of maple, birch, chestnut, oak, beech, apple, pear, quince, cherry, plum, rose, willow, elm, locust, mulberry, &c. among our indigenous and cultivated trees; and in mahogany, orange sandal wood, logwood, lignum-vitæ, and many other exotic species.

In the annexed table is given a more detailed list of the plants in which form A was found. It doubtless could be much extended, but my herbarium is too limited to allow me to make so general an examination as is desirable.

* I use the notation given by Dana, in his excellent System of Mineralogy.

TABLE A.

Dicotyledonous plants containing crystals of form A. (Figs. 4 to 9.)

ACERACEÆ,	Acer, several species. In bark and wood, and along veins of leaf.
ÆSCULACEÆ,	Æsculus hippocastanum. In bark of petiole, a few simple crystals, with abundance of bunches.
APOCYNEÆ,	Nerium oleander.
AQUIFOLIACEÆ,	Prinos catharticus.
AURANTIACEÆ,	Citrus aurantianum. Crystals (see figs. 6, 7, 8) abundant in leaf and petiole, and in pulp of fruit.
BETULACEÆ,	Alnus serrulata.
	Betula excelsa.
	" papyracea.
BALSAMACEÆ,	Liquidambar styraciflua.
CUPULIFERÆ,	Quercus nigra. " tinctoria. " alba. " montana. " phellos. Castanea vesca. " pumila. Fagus sylvatica. Carpinus Americana. Ostrya Virginica. In every species of Cupuliferæ which I have examined, whether indigenous or exotic, great abundance of crystals were found, usually presenting the forms, fig. 6 to 9, but also having bunches (form B, fig. 15) occasionally mingled with them. In many species of this family it is easy to see the crystals *in situ*, in thin layers of the liber. In the chestnut they may be seen thus in great abundance, and disposed in cells, as in fig. 3.
CEDRELACEÆ,	Swietiana Mahagoni. In scrapings of Mahogany wood, and in the ashes, large crystals may be found in abundance.
CORNACEÆ,	Cornus florida. Crystals abundant in the bark.
ERICACEÆ,	Andromeda racemosa. Crystals small; may be seen in ashes of leaf.
	Azalea viscosa. Crystals small.
EBENACEÆ,	Diospyros Virginiana. Large and rather irregular crystals, scattered through the leaves.
FRANKENIACEÆ,	Frankenia lævis. Bunches also.
HAMAMELACEÆ,	Hamamelis Virginica. Crystals abundant in ashes of leaf, along each vein, and easily isolated from the bark.
LEGUMINOSÆ,	Virgilia lutea.
	Psoralea lupinellus.
	Crotalaria sagittalis.

LEGUMINOSÆ, Cassia Chamæcrista.
Æschynomene aspera? In the bark of the plant, used by the Chinese in making what is called *rice paper*.
Lathyrus sativus.
Pisum maritimum. In the ashes of the leaf; the veins are beautifully marked out by the crystals.
Pisum sativum.
Viccia cracca.
Phaseolus.
Lespedeza frutescens.
Trifolium pratense.
Pterocarpus santalinus, red sandal wood.
Cæsalpina Brasiliensis, Brazil wood.
Hæmatoxylon Campeachianum, logwood
The crystals may be found in abundance in the ground dye-stuffs of commerce.
Gleditschia triacanthus.
Robinia pseudacacia. In vast numbers in the liber.
And many others.
Crystals of form A occur in such profusion in all species of Leguminosæ which I have examined, that I have no doubt they belong to the whole family.

PINACEÆ, Pinus strobus. In its bark may be found latex vessels crowded with minute crystals, which are right rhomboidal prisms of 70° and 110°; these are perhaps secondary to form A. (See fig. 12.) In *Torreya taxifolia* the bark contains long vessels *covered* with minute rhombic crystals. (Fig. 14.) The *wood* of the Pine tribe is remarkably free from crystals.

PLATANACEÆ, Platanus occidentalis. Crystals abundant in the bark.

RHAMNACEÆ, Rhamnus catharticus.

ROSACEÆ, Sub-Order *Pomeæ*.
Cratægus.
Pyrus.
Cydonia.
Crystals of form A predominate in Rosaceæ, but bunches (form B) are also mingled with them in the same plant.
Sub-Order *Amygdalæ*.
Prunus.
Cerasus.

ROSACEÆ VERÆ, Rosa rubiginosa. In the sweet brier the oblique rhombic prism unmodified is not unfrequent. (See fig. 4.)
Rosa Carolina.
Spiræa salicifolia.
" tomentosa.
Rubus odoratus. Bunches also.

SALICACEÆ,	Salix. Populus.	In the liber of every species of Willow and Poplar examined by me, the crystals were in profusion, being distributed in cells, as shown in fig. 3, which was taken from *Populus grandidentata.*
SANTALACEÆ,	Nyssa aquatica.	
ULMACEÆ,	Ulmus Americana.	Crystals abundant in bark and leaves.
	Ulmus fulva.	
	Celtis occidentalis.	I am indebted to E. J. Quekett, Esq. of London, for beautiful specimens of these crystals *in situ*, in the *testa* of the seed of Ulmus.
VITACEÆ,	Vitis vulpina. " riparia.	In the bark and veins of the leaves of the different species of this family, occur rows of crystals, showing every modification of form A. Acicular raphides are also very abundant.
VACCINACEÆ,	Vaccinium resinosum.	Crystals resembling those of Diospyros, but smaller.
URTICACEÆ,	Broussonetia papyrifera.	
	Morus tinctoria, (fustic.)	
XANTHOXYLACEÆ,	Xanthoxylum fraxineum.	
	Ailanthus.	Bunches also.
ZYGOPHYLLEÆ,	Guaiacum officinale, (lignum-vitæ.)	Small crystals may be isolated by scraping, and may be seen abundantly in the ashes.

I have also seen in the monocotyledonous plant, Tradescantia Virginica, small crystals which I believe are referable to form A.

The crystals found in the plants enumerated in the above table, agree not only in general form, but the plane angles of the faces P and M, were in many cases measured by the aid of a camera lucida eye-piece, and found to correspond exactly with the measurements above given; (see figs. 5 and 7.) No doubt of the identity in composition of these crystals in the above mentioned plants, can then be felt; and hence instead of analyzing the crystals in each plant, it is only necessary to examine carefully the chemical composition in any one of them, in which the crystals are particularly abundant or easily isolated.

The following are the results of my experiments upon the crystals in locust, (*Robinia pseudacacia.*)

1. The crystals were insoluble in cold or hot water.
2. They dissolve without effervescence in sulphuric, hydrochloric and nitric acids.
3. They are insoluble in acetic and oxalic acids.
4. When heated they become opaque, and are still insoluble in water.
5. The crystals after ignition dissolve with brisk effervescence in acids.
6. The solution of the ignited crystals in acids, gives, when neutralized, (even when diluted,) a white precipitate with oxalate of ammonia.
7. The isolated crystals, when dissolved in sulphuric acid, gave on evaporation abundance of crystals of sulphate of lime, mingled with others having the form and properties of oxalic acid. For form of crystals of oxalic acid, see figures 22 and 23.
8. The bark, when digested for several days in water and alcohol, so as to remove all soluble matters, was then treated with dilute sulphuric acid, and on partial evaporation, the solution gave an abundant crop of crystals of sulphate of lime.
9. The liquid filtered from the sulphate of lime in the last experiment, was allowed to evaporate spontaneously, and well characterized crystals of oxalic acid were obtained.

The first seven experiments just mentioned were performed repeatedly with the aid of Chevalier's apparatus for micro-chemical experiments, by the use of which the effect of heat and chemical reagents upon these minute crystals could be watched without difficulty, and *more* accurate results obtained than if pounds had been submitted to examination. The processes and results in these seven experiments are almost identical with those mentioned by Raspail,* from which he concludes that the crystals in *Iris florentina* are composed of oxalate of lime, but it does not appear that he isolated the acid.

In my eighth and ninth experiments the microscope was not used, but larger portions of the bark were acted upon, and such quantities of sulphate of lime and oxalic acid obtained as fully to confirm the conclusions from the microscopic trials, that the crystals with which the bark was crowded, were composed of oxalate of lime.

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* Nouveau Systeme de Chimie Organique, Vol. III, p. 601.

But as the complete identity in crystalline form of the crystals in all the plants contained in table A, appeared fully established, it follows that unless several isomorphous bodies occur thus crystallized in these plants, the composition must, like the form, be identical in all. This conclusion was confirmed by numerous micro-chemical experiments on the crystals in cherry, poplar, oak, chestnut, &c., and no result at variance with this view was in any case obtained.

The mention by several authors of crystals of phosphate of lime being found in plants, made me search for it frequently, but the invariable result of the experiments on all the crystals of form A was, that when carefully isolated, and then ignited, they left a carbonate insoluble in water and effervescing with acids, showing decidedly that they contain no mineral acid.

I pass now to the examination of the crystals which resemble in form those found in hickory, and which I shall refer to as form B. (See figures 1, 2, 10, and 11.) These forms are far less abundant in *dicotyledonous* plants than the preceding. All the species in which I have detected them are given in the following list.

TABLE B.

Dicotyledonous plants containing crystals of form B. (Figs. 1, 2, 3, 4, 10, and 11.)

CONACEÆ,	Pinus strobus. In the bark sparingly.
	Abies Canadensis.
ERICACEÆ,	Kalmia latifolia.
FRANKENIACEÆ,	Frankenia lævis.
JUGLANDACEÆ,	Carya, every species examined. Form B predominates, but bunches occur also abundantly. (See figs. 1, 2, 10, and 11.)
POLYGALACEÆ,	Krameria, (radix.)
ROSACEÆ, § *Quillajæ*,	Quillaja saponaria. The bark is crowded with crystals of form B, fig. 10.

Among monocotyledonous plants, this form is found abundantly in the Iridaceæ, as Iris, Crocus, Gladiolus, &c.

On comparing the crystals occurring in the different plants contained in table B, such close relations of form were seen to exist, that no doubt was left that they were all modifications of the same primary. Thus we find that in all these forms, the lateral planes are at right angles; which fact has caused them to be

mistaken by some observers for right square prisms, although all the modifications prove that they belong to the monoclinate system. Again, the identity of the corresponding plane angles, indicates that they may all be referred to the same set of axes. They in fact, may all be referred to modifications of a right rhomboidal or oblique rhombic prism. But as these forms belong to the same system as those of table A, and are therefore not incompatible with those forms, it is even possible that they may be modifications of the same primary. I suspect that this is really the case, for the following reasons.

1. The form fig. 10, is sometimes found in plants whose crystals generally belong to form A, fig. 5.

2. The plane angles 70° and 145°, as indicated on fig. 10, are exactly those which would be given by the face P, of form A, fig. 7, if the obtuse lateral edges were replaced by the planes $\breve{e}$, $\breve{e}$.

The idea that forms A and B are derived from the same primary, is supported by the similarity in chemical composition, which appears to be proved by the following experiments.

1. Raspail states,* that the crystals of form B in Orris root, *Iris florentina*, proved to be oxalate of lime.

2. Dr. Torrey informed me that the crystals (fig. 10) found in the South American bark, (*Quillaja saponaria*,) were analyzed by him, and proved to be oxalate of lime.

3. The crystals in hickory, which agree perfectly in form with some of those occurring in Iris and Quillaja, were submitted by me to all the experiments which I performed on those of locust bark, and the results were *identical*, proving beyond a doubt, that they were composed of oxalate of lime.

The kind of crystals to which my attention was next turned, was that of the stellate bunches, (conglomerate raphides, of Quekett.) These I shall refer to as form C; (see fig. 15.) These bunches, being mere aggregates of crystals, may be expected to occur in all plants which contain any crystals, and they are actually found mingled with the crystals of forms A and B, in many plants. Still there are certain families of plants, as the Polygonæ, Malvaceæ, Geraniaceæ, &c., in which the bunches either occur alone or greatly predominate.

A list of all the plants in which these bunches were noticed by me, is given in table C.

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* Nouveau Syst. Chim. Organique, Vol. III, p. 602.

TABLE C.

Dicotyledonous plants containing form C,—conglomerate raphides.
(Figs. 15, 16.)

ARALIACEÆ,	Aralia spinosa. In cells of liber.
	Hedera helix.
BIGNONIACEÆ,	Catalpa cordifolia.
CACTACEÆ,	Opuntia vulgaris. Bunches large, and abundant.
	Echinocactus. I am informed by my friend E. J. Quekett, that two thirds of the weight of a dried Echinocactus was found by him to be composed of crystals in bunches.
CAPRIFOLIACEÆ,	Viburnum pubescens.
	Diervilla Canadensis.
	Symphoria racemosa.
	Sambucus Canadensis.
FRANKENIACEÆ,	Frankenia lævis. Form A also.
EUPHORBIACEÆ,	Acalypha Virginica. Beautiful stellate groups in the leaves; these may be well seen in the ashes.
JUGLANDACEÆ,	Juglans cinerea. Rounded bunches in bark.
	Carya. Form B predominates in Carya, but mingled with bunches. (See figs. 15, 16.)
LYTHRACEÆ,	Lythrum salicaria.
MALVACEÆ,	Althea rosea.
	Hibiscus moscheatus.
NELUMBOACEÆ,	Nelumbium luteum. Bunches exceedingly abundant in leaf, and shown very finely in the ashes.
ONAGRARIACEÆ,	Sub-Order *Halorageæ.*
	Proserpinaca palustris. Bunches.
	In Onagrariaceæ the acicular raphides are generally very abundant.
PASSIFLORACEÆ,	Passiflora lutea. Bunches abundant.
PHILADELPHIACEÆ,	Philadelphus coronarius.
POLYGONIACEÆ,	Every species of Polygonum, Rumex, Rheum, &c. which I have examined, abounds in conglomerate raphides. They are said by Quekett to form 35 to 40 per cent. of the weight of the common Rhubarb, (*Rheum palmatum.*)
ROSACEÆ,	Comarum palustre.
	Rubus odoratus. Bunches, mixed with abundance of simple forms. The white powder which covers the bark after the falling off of the older portions, is chiefly made up of bunches of crystals, among which forms A and B may be recognized.

SALICACEÆ,	Salix. Bunches occur in the parenchyma of the leaves of several species of Willow, while form A predominates in the veins and liber.
TAXACEÆ,	Salisburia adiantifolia. Veins of leaf very beautifully shown in the ashes by rows of large crystalline bunches.
	Taxus Canadensis. Bunches in bark.
TILIACEÆ,	Sparmannia Africana. Bunches exceedingly abundant, with some crystals of form B.
URTICACEÆ,	Ficus carica. If a portion of the pulp of the Fig be compressed between plates of glass, and examined by the microscope, beautiful vascular bundles of spiral vessels, and latex vessels, will be seen, and exterior to these, are rows of cells, with large bunches of crystals.
VALERIANACEÆ,	Centranthus rubus.
VACCINACEÆ,	Vaccinium resinosum.

NOTE.—In tables A, B and C, I have recorded the results of the examination of most of the dicotyledonous plants in which I have detected crystals. I have not recorded the experiments in those cases where I have not been able to detect the crystals, as I attach less importance to merely negative results. Still there are some families in which I am almost certain that they are not to be found, notwithstanding the statement of Unger, quoted by Quekett,* that *all* families contain them, and that they are present even in Ferns, Mosses, and the lowest Algæ. I have repeatedly examined various plants of the great families Compositæ, Labiateæ, Gramineæ, Filices, Musci and Algæ, by all the methods which readily showed crystals in other plants, and as yet have not detected a single crystal in any one of them.

The crystals in the bunches (form C) are usually so crowded, that it is often impossible to determine the form of the single crystals, but in some cases, as in hickory, (figures 15 and 16,) it is possible to find bunches showing pretty distinctly the forms of the simple crystals of which they are made up, and thus enabling us to see that they result from aggregations of forms allied to B or A. In other cases a projecting angle may be measured, or else by crushing the bunch, some of the crystals may be separated, so as to be examined more carefully. All the examinations which I have made in this way have led me to the

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* See Quekett's paper on Raphides, in Lindley's Introduction to Botany, second edition.

conclusion, that these bunches are *generally*, if not always composed of monoclinate forms, referable to forms A or B. The bunches, so abundant in the Turkey rhubarb, (*Rheum palmatum*,) have been repeatedly analyzed and found to be composed of oxalate of lime. In examinations of these bunches in other plants, as in *Salisburia adiantifolia*, *Nelumbium luteum*, &c., I have found that they always left insoluble carbonate of lime on ignition, showing them to be compounds of lime with an organic acid, and in the micro-chemical experiments, where the salts were decomposed by dilute sulphuric acid, the solution evaporated on glass, left crystals of sulphate of lime, mingled with others having the form and properties of oxalic acid.

We may conclude then, both from the crystallographic and chemical examinations, that these bunches are *generally* aggregates of simple crystals, of the same form and composition as forms A and B. It follows then, from the above mentioned results, that in a very great majority of dicotyledonous plants, oxalate of lime in more or less regular crystalline forms may be found, and frequently in great quantity.*

To those who do not properly appreciate the infinitesimal forces of nature, and who do not consider that some of the grandest natural phenomena result from their action, the fact thus established with regard to the minute crystals in plants, may appear of trifling importance. It is true these crystals are minute; so minute that in many trees, as the poplar, locust, willow, &c., they do not exceed $\frac{1}{1250}$th of an inch in length, yet what they want in size they make up in number, and when we come to integrate these infinitesimals, we find that the number contained in a single square inch of a layer of the liber not thicker than a piece of writing paper, is at least a million. (See fig. 3.)

When we now reflect upon the number of such layers contained in the thickness of the bark, and the number of square inches given by the surface of a large tree, including all its branches, and then consider, that in addition to all this, the amount of crystals in the leaves, wood, and roots, is to be taken into account, we find that the number of crystals in a single tree, is enormous, beyond all conception. Yet the greater number of the trees in

* Quekett has succeeded in forming the conglomerate raphides of oxalate of lime, by artificial processes, by saturating the cells of rice paper (*Æschynomene aspera?*) with lime water, and then immersing it in dilute oxalic acid. See Quekett on Raphides in Lindley's Botany.

the forests, not only in this, but in all countries, are as full of these bodies as the example I have just taken.

The establishment of the fact of the general production of oxalate of lime by plants in such vast amount, is not then, unimportant. Such facts have important causes and consequences, many of which may in time be determined. In the present case the inquiry into the *cause* of the general phenomena we have mentioned, is not without interest.

The questions, Whence come the oxalic acid and lime? Is the former produced by the oxidation of starch and sugar in the plant? or what is the way by which it, and the lime are introduced? are all important, but cannot be answered with certainty at present.

The *consequences* too, present a wide field of inquiry.

Has the development of heat and electricity, which must attend the formation of each of these crystals, any important effect on the plants?

For what purpose in the economy of nature, is this enormous production of oxalate of lime? Is this salt a fertilizer?

Are the fall of the leaves, the shedding of the bark, and the rotting of wood, Nature's beautiful methods of distributing this fertilizer over the soil?

Do the lichens upon trees extract their oxalate of lime from them? What change does the salt undergo during the decompositions of vegetable matter? Can it be detected unchanged in soil?

These and many other problems grow out of the subject, and present an ample field for future investigation.

Although in this paper I have shown that the crystalline matter in plants, is *usually* oxalate of lime, I would not be understood to assert that it is always so. Forms incompatible with those belonging to this salt, occur in some plants; thus beautiful little cubes occur sparingly among the starch globules in the tubers of the potato, (see fig. 17,) and in the outer coverings of the bulbs of the onion, and all the species of the genus Allium, elegant right square prisms are disposed in the cells, as shown in fig. 18. In *Rhus typhina*, also, are found flattened octahedrons, and right square prisms; (see figures 19, 20, 21.) Bunches (form C) also occur in the same plant. The crystals in potato and onion, may possibly be one of the phosphates of lime, as phosphoric acid has been detected in both these vegetables. The crystals in Rhus may be malate of lime, as this salt is produced upon the berries

in great quantity. I have, however, not been able to complete my examination of the different anomalous forms just mentioned, nor of the acicular raphides, (said by Raspail to be composed of phosphate of lime,) which are so common in most monocotyledons, and in many dicotyledons. I shall pursue this inquiry as opportunity presents itself, and if any results of interest are obtained, I hope to make them the subject of another part of this memoir.*

EXPLANATION OF THE FIGURES.

The figures are all drawn to the same scale, shown in fig. 24.

Figs. 1 and 2, *a b*. Different positions of crystals, form B, from Hickory, *Carya*.

Fig. 3. Crystals *in situ*, in bark of *Populus grandidentata*. They present the same appearance in the liber of the Locust, Chestnut, Willow, and many other trees.

Fig. 4. Unmodified oblique rhombic prism; occurs in *Rosa rubiginosa*.

Fig. 5. The same form, with the acute edges replaced by the planes *ĕ*, *ĕ*.

Figs. 6 to 8. Different positions of crystals of form A.

Fig. 9. Compound crystal resulting from composition parallel to the plane P; a very common form.

Fig. 10. Crystal of form B, from *Quillaja*, showing the plane angles.

Fig. 11, *a b*. Crystals of form B, found sparingly in bark of Pine.

Fig. 12. Portion of the inner layer of the bark of *Pinus strobus*, showing a fragment of a latex vessel containing crystals.

Fig. 13. Right rhomboidal crystals, isolated, from bark of *Pinus strobus*.

Fig. 14. Conical termination of a vessel from bark of *Torreya taxifolia*, covered with very minute crystals.

Fig. 15. Bunches of crystals (form C) or conglomerate raphides of Quekett.

Fig. 16. Bunch of two crystals only, from *Carya*.

Fig. 17. A single cell from the tubers of Potato, showing small cubical crystals, *a a*, occurring occasionally among the starch globules, *b b*.

Fig. 18. Right square prisms in the cells of the outer coatings of the common Onion.

Figs. 19, 20, 21. Crystals in bark of *Rhus typhina*.

Figs. 22, 23. Crystals of oxalic acid.

Fig. 24. Scale showing $\frac{10}{100}$ths of a millimetre, magnified equally with the drawings.

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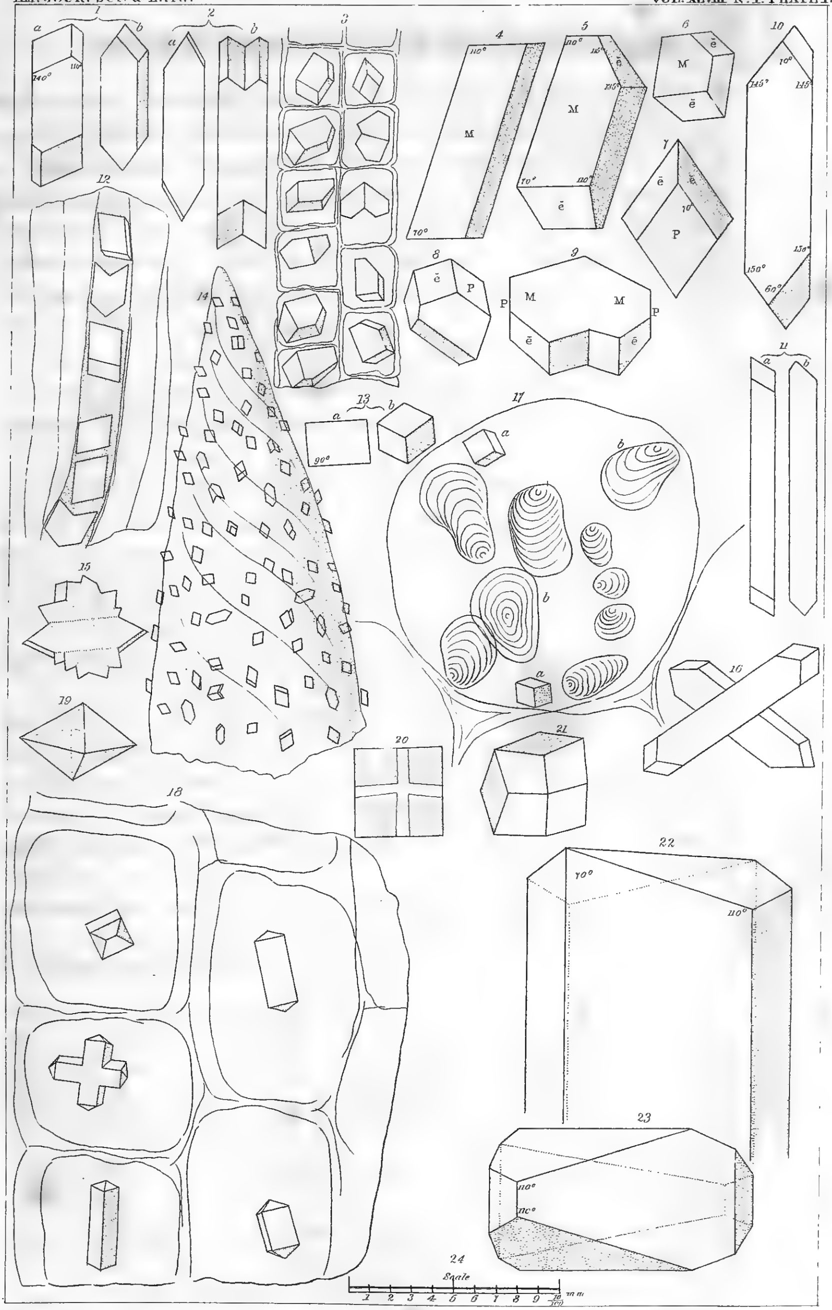
* All the results mentioned in this paper were obtained by me before I heard of Payen's highly interesting researches upon crystals, with which I am even now only acquainted by means of a brief notice in the Microscopic Journal, Vol. II, p. 213.



Prof. Bailey on the Crystals found in Plants.

[illegible]

Art. III.—*Magnetical Investigations;* by the Rev. William Scoresby, B. D.—Part I. London, Longman & Co., 1839. pp. 96.—Part II. London, Longman & Co., 1843. pp. 360.

The knowledge of the attractive property of the native magnet is of remote antiquity, and the possibility of communicating that virtue to iron and steel was perhaps ascertained at a date little less distant. The direction property, of such absolute necessity to the navigator, and so convenient to the land surveyor, was certainly unknown to the polished nations of ancient Europe, but there is reason to suppose that the Chinese, even before the Christian era, were acquainted with it, and used it to guide the courses of caravans upon the land, and of their junks upon the ocean. The use of the needle for the latter purpose, among the western nations of the old continent, is supposed to have been introduced by the navigators of Atnalfi in Italy, although of this there is no positive evidence; but the instrument did not inspire unlimited confidence in the certainty of its indications until the 15th century, when a career of maritime discovery was opened under its influence, which had its proudest triumph in the first voyage of Columbus.

In that eventful expedition, the fact that the needle did not every where point to the poles of the earth, was first detected, and from that time to the present, the variation of the compass has been a subject of close and assiduous study, first as essential for the safety of the navigator, and finally as an important element in the magnetic properties of the earth itself. The simple fact of the existence of the dip could not have escaped any artist who had constructed a compass, but it was not until the middle of the last century, that the dipping needle came to be considered as an essential part of magnetic apparatus, although used by Norman in A. D. 1592.

The probability that the intensity of the magnetic influence varied in different parts of the earth's surface, seems to have been first distinctly pointed out, in the instructions for the voyage of La Perouse, but it was reserved for Humboldt to establish the certainty of this variation in the force, by experiment.

It was also known that these three elements, direction, intensity and dip, were not constant at any given place, and the dis-

covery of these facts is almost cotemporaneous with that of the elements themselves. The fact that there was a discrepancy between the apparent course of the wind, as observed on board a vessel when on two different tacks, had puzzled nautical men; it was reserved for Flinders to point out, that this discrepancy arose from the magnetic action of the iron, which forms so considerable a part of the structure of all vessels, and so large a portion of the equipment of ships of war.

In the practical part of magnetism, some trifling improvements had been made in the mode of communicating magnetism to steel bars, and the fact that the earth itself might be successfully used as a source of the magnetic agency, had been developed before the middle of the last century. Such was the state of our knowledge of magnetism in the early years of the present century, but since that period innumerable important discoveries have been made in its relations to other physical agents, and in the theory of its distribution and action on the surface of the earth. Davy and Oersted have established the knowledge of the intimate connection of magnetism with electricity, and the laws to which this connection is subject have been developed by Ampere, Faraday, and our own Henry. The facts of terrestrial magnetism have been accumulated to an immense amount, by national expeditions, fitted out from France, England and Russia, not to mention those almost sufficient of themselves to give a complete view of the magnetic phenomena of the whole earth, which are about to be published from the records of the United States Exploring Expedition.

From a combination of all known observations, Barlow and Sabine have constructed charts of the isoclinal, isodynamic, and isogonal lines, which have served Gauss as the most important part of the foundation on which he has built up a complete theory of terrestrial magnetism. Nor can we avoid mentioning the contributions of Sabine himself, of Lloyd, Lamont and Hansteen, to the record of facts, nor those of Bache, Locke and Loomis in the United States.

The only part of the whole field of magnetism which appeared to have remained unimproved, was the practical method of magnetizing bars of steel, and this desideratum seems to have been at last attained by the work before us.

It contains the record of a great number of valuable experiments, conducted in the true spirit of scientific inquiry, and

the results are arranged in a lucid and philosophic manner. We have no space to enter into the details of the experiments, but the results are of such interest that we cannot better occupy our pages than in communicating them to our readers.

The relative powers of the magnetized bars and their combinations, were principally determined by their power of deflecting the needle of a given compass. Lest, however, this method should be considered as deficient in accuracy, a sufficient number of comparisons were made between it and the method of torsion, to show that it was to be relied upon, when used in the manner and under the circumstances adopted by Dr. Scoresby.

It appears from the investigations in these volumes;

1. That the magnetic capacity of iron is in proportion to its ductility, a property existing in the highest degree in the purest iron.

2. That steel made from the purest iron possesses the highest magnetical properties.

3. That any single bar or plate of magnetized steel is more powerful or energetic *proportionally*, than two or more corresponding and equal bars; that is to say, that its magnetic force is greater than the half of that exerted by two acting together, and so on.

4. That a combination of bars or plates in contact with each other, is more powerful than any single bar of the same weight, but that the gain of power by each additional plate diminishes progressively.

5. That continual additions to a powerful combination of bars or plates, cease to be beneficial beyond a limited extent, in consequence of the impracticability of obtaining a large series of bars or plates exactly alike.

6. That the gain in power of any combination of bars or plates over equal masses in a solid bar, is greater when the plates, instead of being in contact with each other, are separated; and this augmentation improves as the spaces between them are enlarged.

7. That by the separation of the plates or bars, a larger number of them may be combined to advantage.

8. That temper has a great influence on the relative powers of combinations of steel plates, but that different degrees of temper have different degrees of advantage, in bars or plates of different sizes.

9. That a partial temper or slight degree of hardness, gives most power to small masses, but in permanency of power, hard magnets, whether in large or small masses, are always superior.

10. That after steel has been tempered to the highest degree of hardness, annealing may or may not be beneficial, according to circumstances included in following summary.

a. For large and massive single straight magnets, the best cast-steel, tempered as hard as possible, is to be preferred.

b. For straight-bar compound magnets, the same quality of steel and degree of hardness.

c. For compound magnets of busk-plate, the best cast-steel, tempered to the utmost in boiling linseed oil.

d. For horse-shoe magnets, if in a single bar, cast-steel annealed from file hardness, in a bath of oil at 550°.

e. For compound horse-shoe magnets, cast-steel annealed at from 480° to 500°.

f. For compass needles, if single and heavy, hard cast-steel; if light, whether single or compound, cast-steel annealed at from 500° to 550°.

g. For very light needles, the best cast-steel, annealed in boiling linseed oil.

Art. IV.—*A new way of obtaining the Exponential and Logarithmic Theorems;* by Prof. Theodore Strong.

We shall suppose that a and N denote any two indeterminate quantities, and shall put $\frac{\log.N}{\log.(1+a)}=y$, the logarithms being taken to any arbitrary base; then we shall evidently have $N=(1+a)^y$, (1); for by taking the logarithms of both sides of (1) to the same base as before, we have $\log.N=y.\log.(1+a)=\log.N$, which is an identical equation, as it ought to be.

If we expand the right member of (1) by the binomial theorem, we get $N=1+ya+\frac{y(y-1)}{1.2}a^2+\frac{y(y-1)(y-2)}{1.2.3}a^3+\frac{y(y-1).(y-2).(y-3)}{1.2.3.4}a^4+$&c., which being arranged according to the ascending powers of y, gives $N=1+y\left(a-\frac{a^2}{2}+\frac{a^3}{3}-\frac{a^4}{4}+\right.$

$\frac{a^5}{5}-\&c.\Big)+\frac{y^2}{1.2}\Big(a^2-a^3+\frac{11}{12}a^4-\&c.\Big)+\frac{y^3}{1.2.3}\Big(a^3-\frac{3a^4}{2}+\&c.\Big)$ $+\frac{y^4}{1.2.3.4}(a^4-\&c.)+\&c.$ (2). If we substitute the value of y, in the second member of (2), then since the first member of the equation is independent of a, and a is to be arbitrary, the second member of the equation must also be independent of a, hence we must have $\log.(1+a)=m\Big(a-\frac{a^2}{2}+\frac{a^3}{3}-\frac{a^4}{4}+\&c.\Big)$, (3), and $a^2-a^3+\frac{11}{12}a^4-\&c.=\Big(\frac{\log.(1+a)}{m}\Big)^2$, $a^3-\frac{3a^4}{2}+\&c.=$ $\Big(\frac{\log.(1+a)}{m}\Big)^3$, and so on, where m is an arbitrary quantity which is independent of a; and (2) will become $N=1+\frac{\log.N}{m}+\frac{1}{1.2}$ $\Big(\frac{\log.N}{m}\Big)^2+\frac{1}{1.2.3}\Big(\frac{\log.N}{m}\Big)^3+\&c.$ (4). If we change N into N^x, then since $\log.N^x=x\log.N$, (4) becomes $N^x=1+x\frac{\log.N}{m}+\frac{x^2}{1.2}$ $\Big(\frac{\log.N}{m}\Big)^2+\frac{x^3}{1.2.3}\Big(\frac{\log.N}{m}\Big)^3+\&c.$ (5). If we change a to a', and determine a' from the equation $a'-\frac{a'^2}{2}+\frac{a'^3}{3}-\frac{a'^4}{4}+\&c.=1$, (6), and then put $1+a'=e$, (3) becomes $\log.e=m$, and e will be the base of hyperbolic logarithms. By substituting the value of m in (3) and (5), they will become $\log.(1+a)=\log.e\Big(a-\frac{a^2}{2}+\frac{a^3}{3}-\&c.\Big)$, (7), $N^x=1+x\frac{\log.N}{\log.e}+\frac{x^2}{1.2}\Big(\frac{\log.N}{\log.e}\Big)^2+\frac{x^3}{1.2.3}\Big(\frac{\log.N}{\log.e}\Big)^3+\&c.$, (8), which is the exponential theorem. If we substitute the value of m in (4), and put $N=e$, we get $e=1+1+\frac{1}{1.2}+\frac{1}{1.2.3}+\frac{1}{1.2.3.4}$ $+\&c.$, (8′), which can also be easily obtained from (8); calculating from (8′) the value of e to seven places of decimals, we get $e=2{\cdot}7182818+$ for the value of the base of hyperbolic logarithms; so that if we have the equation $M=e^z$, by the (ordinary) definition of logarithms $z=\log.M$ when e is taken for base, that is, (since $e=$ the base of hyperbolic logarithms,) $z=$ the hyperbolic logarithm of M; we shall denote the hyperbolic logarithm of any quantity by writing L before the quantity, so that L.N,

L.$(p+q)$, denote the hyperbolic logarithms of N and $p+q$. If the logarithms in (7) and (8) are supposed to be taken to the base e, (or are hyperbolic,) then since e is the base, Le=1, and they become L.$(1+a)=a-\frac{a^2}{2}+\frac{a^3}{3}-$&c., (9), $N^x=1+x\text{L.N}+\frac{(x\text{L.N})^2}{1.2}+\frac{(x\text{L.N})^3}{1.2.3}+$&c. (10).

If we suppose that the logarithms in (7) are taken to the base $1+b$, we shall have, since $1+b$ is the base, log.$(1+b)=1$, and by (7) log.$(1+b)=\log.e\left(b-\frac{b^2}{2}+\frac{b^3}{3}-\text{\&c.}\right)=1$, and by (9) we have $b-\frac{b^2}{2}+\frac{b^3}{3}-$&c. $=$ L.$(1+b)$, $\therefore$ by substitution log.$e\times$L.$(1+b)=1$, or $\log.e=\frac{1}{\text{L.}(1+b)}$, and if we put $1+b=$A, $\log.e=\frac{1}{\text{L.A}}$, $\therefore$ substituting this value of log.e in (7), it becomes log.$(1+a)=\frac{1}{\text{L.A}}\left(a-\frac{a^2}{2}+\frac{a^3}{3}-\text{\&c.}\right)$, (11), where $\frac{1}{\text{L.A}}$ is called the modulus of the system of logarithms when A is taken for base; we shall denote the modulus by m, and m will equal unity divided by the hyperbolic logarithm of the number that is taken for base; $\therefore$ since by (9) $a-\frac{a^2}{2}+\frac{a^3}{3}-$&c.$=$L.$(1+a)$, (11) becomes log.$(1+a)=m\left(a-\frac{a^2}{2}+\frac{a^3}{3}-\frac{a^4}{4}+\text{\&c.}\right)=m$L.$(1+a)$, (12), so that to find log.$(1+a)$ we must multiply the hyperbolic logarithm of $(1+a)$ by the modulus; $\therefore$ in the common system where A=10, we have $m=\frac{1}{\text{L.10}}$, and if we multiply the hyperbolic logarithm of any number by this value of m, we shall get the common logarithm of the number.

If we change the sign of a in (12), we get log.$(1-a)=-m\left(a+\frac{a^2}{2}+\frac{a^3}{3}+\frac{a^4}{4}+\text{\&c.}\right)=m$L.$(1-a)$, or (since by the nature of logarithms log.$(1-a)=-\log.\left(\frac{1}{1-a}\right)$), log.$\left(\frac{1}{1-a}\right)=m\left(a+\frac{a^2}{2}+\frac{a^3}{3}+\frac{a^4}{4}+\text{\&c.}\right)=m\text{L}\left(\frac{1}{1-a}\right)$, (13), which added to (12), gives log.$\left(\frac{1+a}{1-a}\right)=2m\left(a+\frac{a^3}{3}+\frac{a^5}{5}+\text{\&c.}\right)=m\text{L}\left(\frac{1+a}{1-a}\right)$, (14); if we

put $\frac{1+a}{1-a}=\frac{p}{q}$, we get $a=\frac{p-q}{p+q}$, and (14) becomes $\log.\frac{p}{q}=2m\left(\frac{p-q}{p+q}+\frac{1}{3}\left(\frac{p-q}{p+q}\right)^3+\frac{1}{5}\left(\frac{p-q}{p+q}\right)^3+\&c.\right)=m\text{L}.\frac{p}{q}$, (15), and if $p-q=r$ or $p=q+r$, (15) becomes $\log.(q+r)=\log.q+2m\left(\frac{r}{2q+r}+\frac{1}{3}\left(\frac{r}{2q+r}\right)^3+\frac{1}{5}\left(\frac{r}{2q+r}\right)^5+\&c.\right)=m\text{L}.(q+r)$, (16), and if we put $r=1$, we get $\log.\left(\frac{q+1}{q}\right)=2m\left(\frac{1}{2q+1}+\frac{1}{3}\left(\frac{1}{2q+1}\right)^3+\frac{1}{5}\left(\frac{1}{2q+1}\right)^5+\&c.\right)=m\text{L}.\left(\frac{q+1}{q}\right)$, (17), $\therefore \text{L}.(q+1)=\text{L}.q+2\left(\frac{1}{2q+1}+\frac{1}{3}\left(\frac{1}{2q+1}\right)^3+\frac{1}{5}\left(\frac{1}{2q+1}\right)^5+\&c.\right)$, (18). Since the logarithm of unity is equal to zero in any system of logarithms, if we put $q=1$ in (18), we have $\text{L}.2=2\left(\frac{1}{3}+\frac{1}{3}\left(\frac{1}{3}\right)^3+\frac{1}{5}\left(\frac{1}{3}\right)^5+\&c.\right)$, which gives the hyperbolic logarithm of 2; then if we put $q=2$ in (18), we get $\text{L}.3=\text{L}.2+2\left(\frac{1}{5}+\frac{1}{3}\left(\frac{1}{5}\right)^3+\frac{1}{5}\left(\frac{1}{5}\right)^5+\&c.\right)$; and if we put $q=4$, (since $\text{L}.4=2\text{L}.2$,) we get $\text{L}.5=2\text{L}.2+2\left(\frac{1}{9}+\frac{1}{3}\left(\frac{1}{9}\right)^3+\frac{1}{5}\left(\frac{1}{9}\right)^5+\&c.\right)$; and if $q=6$, (since $\text{L}.6=\text{L}.2+\text{L}.3$,) we get $\text{L}.7=\text{L}.2+\text{L}.3+2\left(\frac{1}{13}+\frac{1}{3}\left(\frac{1}{13}\right)^3+\frac{1}{5}\left(\frac{1}{13}\right)^5+\&c.\right)$, and so on, to any extent; if we add the hyperbolic logarithms of 2 and 5, we get the hyperbolic logarithm of 10, and if we divide unity by the hyperbolic logarithm of 10, we get the modulus of the common system of logarithms.

Again, if we assume $2=1+1=(1+y).(1+z)=1+y+z+yz$, we get $y=\frac{1-z}{1+z}$, $\therefore$ if we assume $z=\frac{1}{2}$, we get $y=\frac{1}{3}$, and $2=\left(1+\frac{1}{2}\right)\cdot\left(1+\frac{1}{3}\right)$. In a similar way if we assume $1+\frac{1}{2}=(1+y).(1+z)$ we get $y=\frac{\frac{1}{2}-z}{1+z}$, and if we assume $z=\frac{1}{4}$, $y=\frac{1}{5}$, so that $2=\left(1+\frac{1}{3}\right)\cdot\left(1+\frac{1}{4}\right)\cdot\left(1+\frac{1}{5}\right)$, and if we change $\frac{1}{2}$ into $\frac{1}{3}$ in the formula $y=\frac{\frac{1}{2}-z}{1+z}$ and assume $z=\frac{1}{6}$, we get $y=\frac{1}{7}$, so that $2=$

$\left(1+\frac{1}{4}\right)\cdot\left(1+\frac{1}{5}\right)\cdot\left(1+\frac{1}{6}\right)\cdot\left(1+\frac{1}{7}\right)$, and by proceeding in this way, we get $2=\left(1+\frac{1}{5}\right).\left(1+\frac{1}{6}\right)\cdot\left(1+\frac{1}{7}\right)\cdot\left(1+\frac{1}{8}\right)\cdot\left(1+\frac{1}{9}\right)=\left(1+\frac{1}{10}\right)\cdot\left(1+\frac{1}{11}\right)\cdot\left(1+\frac{1}{12}\right)\cdot\left(1+\frac{1}{13}\right)\cdot\left(1+\frac{1}{14}\right)\cdot\left(1+\frac{1}{15}\right)\cdot\left(1+\frac{1}{16}\right)\cdot\left(1+\frac{1}{17}\right)\cdot\left(1+\frac{1}{18}\right)\cdot\left(1+\frac{1}{19}\right)=\left(1+\frac{1}{20}\right)\cdot\left(1+\frac{1}{21}\right)\times\cdots\times\left(1+\frac{1}{38}\right)\cdot\left(1+\frac{1}{39}\right)$, and so on, to any extent; hence since $\text{L}.2=\text{L}.\left(1+\frac{1}{2}\right)+\text{L}.\left(1+\frac{1}{3}\right)$, we get by (9) $\text{L}.2=\frac{1}{2}-\frac{1}{2}\left(\frac{1}{2}\right)^2+\frac{1}{3}\left(\frac{1}{2}\right)^3-\text{\&c.}+\frac{1}{3}-\frac{1}{2}\left(\frac{1}{3}\right)^2+\frac{1}{3}\left(\frac{1}{3}\right)^3-\text{\&c.}=\frac{1}{2}+\frac{1}{3}-\frac{1}{2}\left(\left(\frac{1}{2}\right)^2+\left(\frac{1}{3}\right)^2\right)+\frac{1}{3}\left(\left(\frac{1}{2}\right)^3+\left(\frac{1}{3}\right)^3\right)-\frac{1}{4}\left(\left(\frac{1}{2}\right)^4+\left(\frac{1}{3}\right)^4\right)+\text{\&c.}=\frac{1}{3}+\frac{1}{4}+\frac{1}{5}-\frac{1}{2}\left(\left(\frac{1}{3}\right)^2+\left(\frac{1}{4}\right)^2+\left(\frac{1}{5}\right)^2\right)+\frac{1}{3}\left(\left(\frac{1}{3}\right)^3+\left(\frac{1}{4}\right)^3+\left(\frac{1}{5}\right)^3\right)-\text{\&c.}$ and so on, by which means the hyperbolic logarithm can be found by rapidly converging series. Also since $3=2+1=2\left(1+\frac{1}{2}\right)=\left(1+\frac{1}{2}\right)\cdot\left(1+\frac{1}{3}\right)\cdot\left(1+\frac{1}{2}\right)=\left(1+\frac{1}{2}\right)^2\cdot\left(1+\frac{1}{3}\right)=\left(1+\frac{1}{4}\right)^2\cdot\left(1+\frac{1}{5}\right)^2\cdot\left(1+\frac{1}{6}\right)\cdot\left(1+\frac{1}{7}\right)$, and so on, we may find the hyperbolic logarithm of 3, in a similar way by a rapidly converging series, without making it depend on the logarithm of 2, as is commonly done by using (18).

From what has been done, it is evident that if n denotes any quantity, we shall have $1+\frac{1}{n}=\left(1+\frac{1}{2n}\right)\cdot\left(1+\frac{1}{2n+1}\right)=\left(1+\frac{1}{4n}\right)\cdot\left(1+\frac{1}{4n+1}\right)\cdot\left(1+\frac{1}{4n+2}\right)\cdot\left(1+\frac{1}{4n+3}\right)=\text{\&c.}$ (a); and if M denotes any positive integer greater than unity, (since $\text{M}=\text{M}-1+1$,) we get $\text{M}=(\text{M}-1).\left(1+\frac{1}{\text{M}-1}\right)$, and if $\text{M}-1$ is greater than unity, we have $\text{M}-1=(\text{M}-2).\left(1+\frac{1}{\text{M}-2}\right)$, and if $\text{M}-2$ is greater than unity, we have $\text{M}-2=(\text{M}-3).\left(1+\frac{1}{\text{M}-3}\right)$, and so on; and by these reductions we shall finally get $\text{M}=\left(1+\frac{1}{1}\right)\cdot$

$\left(1+\frac{1}{2}\right)\cdot\left(1+\frac{1}{3}\right)\cdots\times\left(1+\frac{1}{M-1}\right)$, and by ($a$) we shall have $M=\left(1+\frac{1}{2}\right)\cdot\left(1+\frac{1}{3}\right)\cdot\left(1+\frac{1}{4}\right)\cdot\left(1+\frac{1}{5}\right)\cdots\left(1+\frac{1}{2M-2}\right)\cdot\left(1+\frac{1}{2M-1}\right)=$ &c. (b), by putting $M=M-b+b=(M-b)\cdot\left(1+\frac{b}{M-b}\right)$ and $M-b=(M-b-c)\cdot\left(1+\frac{c}{M-b-c}\right)$, and so on, ($b$, c, &c. being arbitrary numbers,) we may obtain an equation which is more general than (b); by (9) we may find the hyperbolic logarithm of M, by rapidly converging series, as in the case of the hyperbolic logarithm of 2. (16) is easily changed to $L\left(1+\frac{r}{q}\right)=2\left[\frac{1}{1+\frac{2q}{r}}+\frac{1}{3}\left(\frac{1}{1+\frac{2q}{r}}\right)^3+\frac{1}{5}\left(\frac{1}{1+\frac{2q}{r}}\right)^5+\text{\&c.}\right]$, (19), and if we put $r=1$, (19) becomes $L\left(1+\frac{1}{q}\right)=2\left(\frac{1}{2q+1}+\frac{1}{3}\left(\frac{1}{2q+1}\right)^3+\frac{1}{5}\left(\frac{1}{2q+1}\right)^5+\text{\&c.}\right)$, (20), which can also be applied to find the hyperbolic logarithm of M, as given in (b); thus since we have $L.2=L.\left(1+\frac{1}{2}\right)+L.\left(1+\frac{1}{3}\right)$, if we put successively $q=2$, $q=3$, we get by (20), $L.\left(1+\frac{1}{2}\right)=2\left(\frac{1}{5}+\frac{1}{3}\left(\frac{1}{5}\right)^3+\frac{1}{5}\left(\frac{1}{5}\right)^5+\text{\&c.}\right)$, and $L\left(1+\frac{1}{3}\right)=2\left(\frac{1}{7}+\frac{1}{3}\left(\frac{1}{7}\right)^3+\frac{1}{5}\left(\frac{1}{7}\right)^5+\text{\&c.}\right)$, whose sum $=L.2=0.693147+$, also if in the formula $M=(M-b).\left(1+\frac{b}{M-b}\right)$, we put $M=10$, $b=2$, we get $10=8\left(1+\frac{1}{4}\right)=2^3\left(1+\frac{1}{4}\right)$, $\therefore L.10=3.L.2+L.\left(1+\frac{1}{4}\right)=2.079441+2\left(\frac{1}{9}+\frac{1}{3}\left(\frac{1}{9}\right)^3+\frac{1}{5}\left(\frac{1}{9}\right)^5+\text{\&c.}\right)$, by (20), $\therefore L.10=2.302585+$, hence the modulus of the common system of logarithms is easily found, and we shall have (the modulus) $m=\frac{1}{L.10}=0.434294+$; and it may be observed that (20) will generally be found more convenient in practice when applied to M,

(when put under the form (b),) than the formulæ deduced (as above) from (9). Before proceeding further, it will be convenient to premise the following principle, viz. if we have the expression $1+Az+Bz^2+Cz^3+\&c.$ where A, B, C, &c. are quantities that are independent of z, we may evidently (without supposing the solution of equations,) assume $1+Az+Bz^2+Cz^3+\&c. =(1+az).(1+bz).(1+cz)\times\&c.$, ($a'$), supposing the number of factors in the second member of the equation to be equal to the index of the highest power of z, in the first member of the equation; for by actually multiplying the factors together, the second member of the equation has the same form as the first member, and since the equation is to be identical, we must have $a+b+c +\&c.=A$, $ab+ac+ad+\&c.+bc+bd+\&c.=B$, $abc+abd+\&c. +bcd+\&c.=C$, and so on, (b'). Since (a') is true for all values of z, we may change z into $z+y$, and we shall have $1+Az+ Bz^2+Cz^3+\&c.+[A+2Bz+3Cz^2+\&c]y+\&c.=(1+az). (1+bz).(1+cz).\&c.+[(1+bz).(1+cz).\&c.]ay+[(1+az). (1+cz).\&c.]by+[(1+az).(1+bz).\&c.]cy+\&c.$, or reducing by ($a'$), and equating the co-efficients of y, (since the equation is to be identical,) also dividing the two members of the resulting equation by the corresponding members of (a'), we get

$$\frac{A+2Bz+3Cz^2+\&c.}{1+Az+Bz^2+Cz^3+\&c.}=\frac{a}{1+az}+\frac{b}{1+bz}+\frac{c}{1+cz}+\&c., \ (c).$$

Since $a+b+c+\&c.=A$, if we put $a^2+b^2+c^2+\&c.=Q$, $a^3+b^3+c^3+\&c.=R$, $a^4+b^4+c^4+\&c.=S$, and so on, and then convert the fractions in the second member of (c) into series arranged according to the ascending powers of z, and then multiply by $1+Az+Bz^2+\&c.$, we shall get the identical equation $A+2Bz+3Cz^2+4Dz^3+\&c.=[1+Az+Bz^2+Cz^3+\&c.]\times [A-Qz+Rz^2-Sz^3+\&c.]$, ∴ performing the multiplication and equating the co-efficients of like powers of z, we get (after slight reductions) $A=A=a+b+\&c.$, $Q=A^2-2B$, $R=AQ- AB+3C=A^3-3AB+3C$, $S=AR-BQ+AC-4D=A^4- 4A^2B+2B^2+4AC-4D$, and so on, ($e$), whose law of continuation is evident; these results agree with those given by Euler at p. 129 of his Analysis of Infinites.

We now observe that if in (10) we put $N=e=$ the hyperbolic base, since $L.e=1$, we shall have $e^x=1+x+\frac{x^2}{1.2}+\frac{x^3}{1.2.3}+\frac{x^4}{1.2.3.4} +\&c.$, ($f$), and if in this we put successively $x=v\sqrt{-1}$,

$x=-v\sqrt{-1}$, we shall get $e^{v\sqrt{-1}}=1+v\sqrt{-1}-\frac{v^2}{1.2}-\frac{v^3\sqrt{-1}}{1.2.3}+\frac{v^4}{1.2.3.4}+\frac{v^5\sqrt{-1}}{1.2.3.4.5}-$&c., $e^{-v\sqrt{-1}}=1-v\sqrt{-1}-\frac{v^2}{1.2}+\frac{v^3\sqrt{-1}}{1.2.3}+\frac{v^4}{1.2.3.4}-\frac{v^5\sqrt{-1}}{1.2.3.4.5}-$&c.; $\therefore$ by addition, subtraction, &c. we get $\frac{e^{v\sqrt{-1}}+e^{-v\sqrt{-1}}}{2}=1-\frac{v^2}{1.2}+\frac{v^4}{1.2.3.4}-\frac{v^6}{1.2.3.4.5.6}+$ &c., (g), $\frac{e^{v\sqrt{-1}}-e^{-v\sqrt{-1}}}{2\sqrt{-1}}=v-\frac{v^3}{1.2.3}+\frac{v^5}{1.2.3.4.5}-$&c., ($h$).

By adding the squares of $\frac{e^{v\sqrt{-1}}-e^{-v\sqrt{-1}}}{2\sqrt{-1}}$ and $\frac{e^{v\sqrt{-1}}+e^{-v\sqrt{-1}}}{2}$, we get $\frac{e^{2v\sqrt{-1}}-2+e^{-2v\sqrt{-1}}}{-4}+\frac{e^{2v\sqrt{-1}}+2+e^{-2v\sqrt{-1}}}{4}=1$, $\therefore$ since the sum of the squares of the sine and cosine of any angle $=1$, (when the radius = unity,) if we put $\frac{e^{v\sqrt{-1}}-e^{-2v\sqrt{-1}}}{2\sqrt{-1}}=\sin.pv$, we must have $\frac{e^{v\sqrt{-1}}+e^{-v\sqrt{-1}}}{2}=\cos.pv$, ($k$), or $v-\frac{v^3}{1.2.3}+\frac{v^5}{1.2.3.4.5}-$&c.$=\sin.pv$, $1-\frac{v^2}{1.2}+\frac{v^4}{1.2.3.4}-$&c.$=\cos.pv$, ($k'$), where p is a constant which is to be found. By (k) we get $\frac{\sin.pv}{\cos.pv}=\tan.pv=\frac{e^{2v\sqrt{-1}}-1}{\sqrt{-1}.\left(e^{2v\sqrt{-1}}+1\right)}$, or $1+\tan.pv\sqrt{-1}=e^{2v\sqrt{-1}}[1-\tan.pv\sqrt{-1}]$, $\therefore e^{2v\sqrt{-1}}=\frac{1+\tan.pv\sqrt{-1}}{1-\tan.pv\sqrt{-1}}$, and taking the hyperbolic logarithm we get $2v\sqrt{-1}=\text{L}.\left(\frac{1+\tan.pv\sqrt{-1}}{1-\tan.pv\sqrt{-1}}\right)$, and the second member of this by (14), (using $\tan.pv\sqrt{-1}$ for a,) gives by a slight reduction $v=\tan.pv-\frac{\tan.^3pv}{3}+\frac{\tan.^5pv}{5}-$&c., ($l$), and dividing $\sin.pv$ by $\cos.pv$ as given by (k'), we get $\tan.pv=v+\frac{v^3}{3}+\frac{2v^5}{3.5}+$ &c.,

(*m*). Now (as is well known) we have $\tan.pv > pv > \sin.pv$, or substituting the values of $\tan.pv$, $\sin.pv$, we get $v+\frac{v^3}{3}+$&c. $>pv>v-\frac{v^3}{1.2.3}+$&c., or $1+\frac{v^2}{3}+$&c.$>p>1-\frac{v^3}{1.2.3}+$&c., (the sign $>$ not excluding equality,) which requires that $p=1$, for the inequality must obtain when v is diminished in infinitum, $\therefore$ by the first condition p is not >1, and by the second p is not <1, $\therefore p=1$; the same result is evident from the circumstance that $v-\frac{v^2}{1.2.3}+$&c. is the development of $\sin.pv$, $\therefore$ since p and v are equally involved in $\sin.pv$, they must be equally involved in the development, that is, v must have p as a factor in the development, so that $pv=v$, and $p=1$.

Hence we get $\sin.v=v-\frac{v^3}{1.2.3}+\frac{v^5}{1.2.3.4.5}-$&c., $\cos.v=1-\frac{v^2}{1.2}+\frac{v^4}{1.2.3.4}-$&c., $v=\tan.v-\frac{\tan.^3v}{3}+\frac{\tan.^5v}{5}-$&c., (A) and (*k*) become $\frac{e^{v\sqrt{-1}}-e^{-v\sqrt{-1}}}{2\sqrt{-1}}=\sin.v$, $\frac{e^{v\sqrt{-1}}+e^{-v\sqrt{-1}}}{2}=\cos.v$, (A′); we can easily deduce the known formulæ for the sines, cosines, tangents, &c. of the sum and difference of any two arcs (rad.$=1$) from (A′), but as the process is sufficiently simple and obvious, we shall not stop to give it. If we denote the semi-circumference of a circle whose radius equals unity by π, then since $\sin.v=0$, when $v=0$, $v=\pi$, $v=-\pi$, $v=2\pi$, $v=-2\pi$, $v=3\pi$, $v=-3\pi$, and so on; we shall have $\sin.v=v\left(1-\frac{v}{\pi}\right)\left(1+\frac{v}{\pi}\right)\left(1-\frac{v}{2\pi}\right)\left(1+\frac{v}{2\pi}\right)\cdot\left(1-\frac{v}{3\pi}\right)\cdot\left(1+\frac{v}{3\pi}\right)\times$&c.$=v\left(1-\frac{v^2}{\pi^2}\right)\cdot\left(1-\frac{v^2}{4\pi^2}\right)\cdot\left(1-\frac{v^2}{9\pi^2}\right)\times$ &c., (B); also $\cos.v=0$, when $v=\pm\frac{\pi}{2}$, $v=\pm\frac{3}{2}\pi$, $v=\pm\frac{5\pi}{2}$, and so on, $\therefore$ we shall have $\cos.v=\left(1-\frac{2v}{\pi}\right)\cdot\left(1+\frac{2v}{\pi}\right)\times\left(1-\frac{2v}{3\pi}\right)\cdot\left(1+\frac{2v}{3\pi}\right)\times$ &c. $=\left(1-\frac{4v^2}{\pi^2}\right)\cdot\left(1-\frac{4v^2}{9\pi^2}\right)\cdot\left(1-\frac{4v^2}{25\pi^2}\right)\times$ &c., (B′). By comparing the values of $\sin.v$, as given by (A) and (B), we get $v-\frac{v^3}{1.2.3}+\frac{v^5}{1.2.3.4.5}-$&c.$=v\left(1-\frac{v^2}{\pi^2}\right)\cdot\left(1-\frac{v^2}{4\pi^2}\right)$

$\cdot\left(1-\frac{v^2}{9\pi^2}\right)\times$&c., which must be an identical equation, its second member being the factors of the first member; or omitting the factor v, and putting $\frac{v^2}{\pi^2}=z$, we get $1-\frac{\pi^2}{1.2.3}z+\frac{\pi^4}{1.2.3.4.5}z^2-$&c. $=(1-z).\left(1-\frac{z^2}{4}\right)\left(1-\frac{z^2}{9}\right)\times$&c.; $\therefore$ by equating the co-efficients of the same powers of z, in the two members of the equation, using the notation in (a'), and the results in (e), we get $A=-\frac{\pi^2}{6}=-\left(1+\frac{1}{4}+\frac{1}{9}+\frac{1}{16}+\&c.\right)$, $B=\frac{\pi^4}{120}$, $C=-\frac{\pi^6}{5040}$, and so on; $\therefore 1+\frac{1}{2^2}+\frac{1}{3^2}+\frac{1}{4^2}+\&c.=\frac{\pi^2}{6}$, $Q=1+\frac{1}{2^4}+\frac{1}{3^4}+\frac{1}{4^4}+\&c.=A^2-2B=\frac{\pi^4}{90}$, $-R=1+\frac{1}{2^6}+\frac{1}{3^6}+\&c.=-(A^3-3AB+3C)=\frac{\pi^6}{945}$, and so on; which agree with the results obtained by Euler at p. 131 of his Analysis of Infinites: and by comparing the value of cos.v given in (A) with its value given by (B′), we have $1+\frac{1}{3^2}+\frac{1}{5^2}+\&c.=\frac{\pi^2}{8}$, $1+\frac{1}{3^4}+\frac{1}{5^4}+\&c.=\frac{\pi^4}{96}$, and so on; as Euler has given them at p. 132. We shall now resume $M=(1+1).\left(1+\frac{1}{2}\right)\cdot\left(1+\frac{1}{3}\right)\times\ldots\left(1+\frac{1}{M-1}\right)$, and by supposing M to be infinite, we have $M=(1+1).\left(1+\frac{1}{2}\right)\cdot\left(1+\frac{1}{3}\right)\cdot\left(1+\frac{1}{4}\right)\times$ &c. to infinity; $\therefore$ by taking the hyperbolic logarithm, we get L.M$=$ $\left(1+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\&c.\text{ to inf.}\right)-\frac{1}{2}\left[1+\frac{1}{2^2}+\frac{1}{3^2}+\&c.\text{ to inf.}\right]+\frac{1}{3}\left[1+\frac{1}{2^3}+\frac{1}{3^3}+\&c.\text{ to inf.}\right]-$&c., or L.M$=\left(1+\frac{1}{2}+\frac{1}{3}+\&c.\right)-\left[\frac{1}{2}\left[1+\frac{1}{2^2}+\frac{1}{3^2}+\&c.\right]-\frac{1}{3}\left[1+\frac{1}{2^3}+\frac{1}{3^3}+\&c.\right]+\&c.\right]$, where the quantity within the braces is evidently positive, we shall denote it by A, and we shall have $1+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+$&c. to infin.$=$L.M$+$A, $\therefore$ since M is infinite its logarithm is infinite, $\therefore$ the sum of the series $1+\frac{1}{2}+\frac{1}{3}+$&c. continued to infinity is infinite.

Art. V.—*Analysis of Coprolites from the New Red Sandstone formation of New England;* by Samuel L. Dana, M. D.—*with remarks by* Prof. Hitchcock.*

Lowell, September 22, 1843.

Prof. Hitchcock,—

Dear Sir—I received a few days ago the sample of supposed coprolite. I set about its analysis immediately, feeling no small interest in the results. I send you those at which I have arrived. The quantity however which I received, was too small to allow me to verify some of the results by repetition, which I shall do when I may have another sample.

Water, organic matter, urate, and volatile salts of ammonia,	10·30
Chloride of sodium,	·51
Sulphates of lime and magnesia,	1·75
Phosphate of lime and magnesia,	39·60
Carbonate of lime,	34·77
Silicates,	13.07
	100·

These results authorize the conclusion, that this substance is coprolite. The evidence of the existence of urate of ammonia is not as satisfactory as one could wish. It is this,—

1. Removing the muriates by alcohol, the insoluble mass was largely digested in water. This last was treated by nitrate of silver, which produced general turbidness; which was followed by a purple red precipitate, which remained unchanged in color for twenty four hours. This precipitate heated in a platina spoon did not melt, but left a filmy scoria, which, under a magnifier, appeared to contain metallic globules—doubtless reduced silver. These characters belong to urate of ammonia.

2. Having treated another portion with alcohol, it was then boiled with water; the solution evaporated, before it became dry, distinct globules of yellowish liquor collected around the upper edge of the evaporating dish, and pushing the operation to dryness, a yellow crust remained, which solved with effervescence

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* The letters of Dr. Dana formed part of the Report on Fossil Footmarks by Prof. Hitchcock, to be found in Vol. xlvii, p. 292; but for want of room their publication was postponed to the present time.

in dilute nitric acid. These are marks of uric acid. But on concentrating the nitric solution, I failed to produce murexide. Had the last been obtained, the evidence of the presence of uric acid would have been decisive. The quantity I operated on may have been too small to allow such a result to have been observed.

When we reflect that some specimens of guano contain less than one per cent. of uric acid, we may well suppose that excrements deposited, ages perhaps, before the oldest guano was evacuated, have undergone changes by which their urates have disappeared. If this has been found in the sandstone of your bird tracks, doubtless the consolidation of that has produced heat enough to carbonize the urates in part; and this is probably the source of the organic matter of the substance you sent for analysis. This matter is insoluble in caustic potash, like insoluble geine. If we are not allowed to consider the evidence of the existence of urates decisive, still we may call this substance, from its other characters, coprolite. I could detect a trace of uric acid on treating it with caustic potash, after removing all soluble salts by water and alcohol.

The phosphoric acid was precipitated by lead, and its amount determined from the phosphate of lead. There are traces of alumina, which I suppose proceeded from the silicates, and I have included its amount in those.

[At my request, Dr. Dana sent me the following extract from his laboratory note-book, detailing his experiments upon the coprolite so far as the phosphates are concerned.—E. H.]

Note-book No. 16, p. 42, *Coprolite?* This is a sample pulverized, sent by Prof. Hitchcock.

Sept. 7.—1.

2. Effervesces violently with muriatic acid, nearly all solves; a black powder remains.

3. Gives off by heat a pungent smell, and a glass rod held over it moistened with muriatic acid, shows white clouds, (ammonia.)

4. Rubbed up with caustic lime and treated with a drop of potash, gave traces of clouds by muriatic acid.

6. The muriatic solution (2) was precipitated by ammonia, copious white gelatinous precipitate, which very slowly subsides.

9. The precipitate (6) solves in part in acetic acid, but a portion, say one third, remains unsolved even in boiling acetic acid —is therefore *phosphate of lime.*

(This you know is now the favorite mode of Daubeny, Johnston, and others, of detecting phosphates in soils. I tried it because it was ready and easy. Let it go for what it is worth.)

Page 42.—12. The water solution by muriate of barytes shows slight traces of sulphuric acid.

Sept. 8.—1st. 3 grains heated to redness.

2. This solves with brisk effervescence in nitric acid, and leaves unsolved dark brick red ashes. The nitric solution being treated with nitrate of silver, no cloudiness occurs; but on neutralizing the acid, an abundant *yellow* precipitate occurs. Hence *phosphoric acid* unequivocally.

Sept. 9.—The solution of mixed nitrates and phosphates was treated by acetate of lead. Copious precipitate of phosphate of lead occurred.

Had this been due to any sulphates, (I allow it may have been in part, but then the traces of sulphates should have been vastly greater,) it is to be recollected that heat and carbonaceous matter would destroy sulphuric acid.

Sept. 10.—A few grains of the substance boiled in dilute caustic potash.

Sept. 11.—On the addition of the caustic potash to the above powder in boiling, distinct clouds with muriatic acid were obtained. Ammonia.

I do not think it worth while here to extend my experiments with the watery solution of nitrate of silver. They show certainly organic matter.

[An additional quantity of coprolite was forwarded to Dr. Dana, which he acknowledges in the following letter of November 19, 1843, with an account of farther experiments upon the portion previously sent.—E. H.]

I received the parcel of coprolite by Mr. Vaill. I am now at work upon it. Before he arrived I began with what of the old stock remained. I found a small portion in one of my test tubes, which had been treated only by alcohol and water. Let us call this No. 1. No. 2, the remains of that treated with caustic potash for uric acid, &c. No. 3, the precipitated phosphate of silver. No. 4, the phosphate of lead obtained in my analysis.

No. 1, was slowly treated, cold, in pure nitric acid—the solution decanted and treated with nitrate of silver. On neutralizing the pure acid, a dirty yellow fell. The ammonia in excess, a copious gelatinous precipitate fell, which was digested some hours, cold, in acetic acid. Nitrate of silver produced in this a copious bright yellow, which subsided rapidly and blackened in the sun. The digestion with acetic acid was several times repeated. The mass insoluble in acetic acid, was then treated with warm dilute caustic potash, which solved traces of alumina, which was detected by the usual mode; while the alkali itself became partly converted into phosphate of potash, which was evident by its solution, (neutralizing by muriatic acid,) precipitating muriate of lime. The mass all solved by acetic acid and by potash, was then examined and found to consist of iron, lime, and phosphoric acid; which last was converted into phosphate of silver with its usual decided characters.

No. 2. I could not suppose that my examination of this for uric acid had decomposed the phosphates. I examined it as above, and again found phosphoric acid. The great bulk of No. 2, however, I submitted to *the latest test proposed by Liebig*, *for earthy phosphates.* It was solved in muriatic acid, the solution treated with perchloride of iron, and the whole precipitated by ammonia. The precipitate was then digested with sulphuret of ammonium. The phosphoric acid if present, would be now converted into phosphate of ammonia; on adding sulphate of magnesia to this, a *triple* phosphate precipitated. In order to be sure of this, the triple phosphate was examined and converted readily into phosphate of silver.

No. 3. The precipitated phosphate of silver was now examined. It proved to be such, and will be further noticed after No. 4.

No. 4. Phosphate of lead, from which I had deduced the quantity of phosphoric acid. It solved in dilute nitric acid without effervescence; wholly soluble, with the exception of a very minute portion, a dirty gray looking white. The solution was treated by sulphuric acid. After the sulphate of lead had subsided, the clear solution, decanted, was found to contain *traces both of iron and alumina;* these being separated, the solution readily afforded, with magnesia, triple phosphate. Another portion, decanted from the sulphate of lead, was also treated by excess of ammonia. The precipitate boiled with caustic pot-

ash, dilute; the clear solution neutralized exactly with muriatic acid, and then treated with muriate of lime, let fall copious flocks. These solved, without a trace of a bubble escaping, in dilute muriatic acid; this last solution let fall, when it was saturated with lime water, copious flocks. These flocks can be only phosphate of lime. You will have observed all along, how obstinately a little iron and alumina adhere to the precipitated phosphate of lead and silver. Still these were separated. But their amount in the lead cannot materially affect the proportion of phosphate of lime I sent you. The same is true of the amount of sulphate in the precipitated phosphate of lead. I presume these results establish the presence of phosphoric acid. Still to leave no stone unturned, I had reserved all the above precipitates of supposed phosphate of silver; they were solved in dilute nitric acid. The silver was separated by muriatic acid, and the excess of acid, then nearly neutralized by pure carbonate of soda, and the following trials made with it.

a. To the solution add pure muriate of lime, no effect; but on neutralizing with pure ammonia, a copious white precipitate, easily soluble in acid, without effervescence.

b. The solution was rendered slightly alkaline by ammonia; became opalescent, but on the addition of sulphate of magnesia, a copious precipitate.

c. The muriate of lime used was rendered a little alkaline by ammonia. There was no change; but on adding the solution of supposed phosphate of soda as above, a copious precipitate.

d. Solution of sulphate of magnesia, dissolve in it cold, a few grains of sesquicarbonate of ammonia. No change; but on adding some of the solution of the supposed phosphate of soda, immediate flocks.

e. The solution above was treated by lime-water, when copious white flocks precipitated. Other trials also were made, and triple phosphate of magnesia and ammonia formed. These several precipitates of supposed phosphate of lime and of triple phosphates were collected in two separate parcels, and the phosphate of lime washed, and then tried as follows:

1st. It solves without a shade of effervescence in dilute nitric acid. A portion of this solution, treated with nitrate of silver and then neutralized by ammonia, gave freely a fine yellow precipitate. This slowly blackens in light. It has every character of phosphate of silver.

2d. The phosphate of lime and triple phosphate were converted into phosphate of lead, each separately. The phosphate of lead from the phosphate of lime was then fused before the blowpipe. It cooled into a fine crystalline mass, as phosphate of lead should. The phosphate of lead from the triple phosphate was fused and the flame continued. It burned off with a beautiful phosphorescent green-yellow flame, and the lead was reduced. I have spread the facts before you. The phosphoric acid does not exist in traces only, but forms a very large portion of the coprolite. Now this substance is too precious to be wasted in further trials for phosphate. I want to reserve as much as I can for other points.

[The next communication, dated Nov. 21st, presents the evidence of the existence of urates in the coprolites.—E. H.]

My last letter, despatched to you a few days after Mr. Vaill's visit, contained the proofs of the presence of phosphates in your coprolite. I have now the pleasure to add, that *uric acid* exists in the same beyond all possibility of doubt. I have not come to this conclusion till after a most patient and critical examination of all my former results, on which I grounded my belief of its existence, added to my recent researches on the second parcel you sent, labelled "coprolite, entirely so, from the same specimen as that which I sent you." What before was highest probability, is now *certainty*. I had then failed to obtain the pinky color, one, as Liebig well remarks, of the peculiar characteristics of uric acid. I had then procured only yellow; which, I may say, is almost equally characteristic, and is always the consequence of too much acid, or too much heat. The quantity of urate I have been obliged to operate upon, at any one time, has been so small, that to produce the pinky color was a matter of no small nicety; but I have succeeded in so doing several times. In my former trials you may remember, that after treating the coprolite by alcohol and boiling water, I followed with caustic potash, and obtained traces of what I supposed to be uric acid. I find in a second trial, by repeated washing of the mass by water, that such a result was not obtained. I concluded, therefore, that uric acid existed in a soluble urate, and from other trials, chiefly as urate of ammonia with some lime. It is to be looked for in the alkaline and watery solution of the coprolite. My inquiries were at last directed only to the educts so obtained.

Alcohol, sp. gr. 0·832, dissolves, by cold digestion, muriate of soda and a little organic coloring matter. This being evaporated dry and redissolved in water, gave, by spontaneous evaporation, a mass of cubic crystals, which by sulphuric acid evolved muriatic acid. They gave no trace of potash nor ammonia by muriate of platina; nor of ammonia by caustic potash. On treating the solution of these crystals in water by nitrate of silver, to determine the quantity of chlorine present, the whole immediately became milky, and by transmitted light, slightly yellow. The whole soon subsided into yellow brown flocks, which were followed by gray flocks. After some hours the clear solution was decanted, and the flocks treated with ammonia to solve the chloride of silver. The whole liquor became immediately of a brown color, and the flocks so minutely divided as to appear a complete solution. They soon collected at the bottom, and the liquor become colorless. The undissolved flocks, which I supposed to be urate of silver, though I did not expect to find urates in the alcoholic solution, were collected and treated with nitric acid. Being evaporated nearly dry, began to turn yellow. I found nitric acid in excess, and exposed the evaporating dish to the vapor of pure ammonia; the mass became *orange red*, and on heating, decidedly and distinctly *pinky*. The clear liquor —the ammoniacal solution—which had been decanted from the brown flocks, seems by the excess of ammonia to have robbed them of a portion of their acid, or perhaps a bi-urate had fallen; for on evaporating the solution and treating it with nitric acid, a brownish and pinky residuum was left. By inverting the evaporating dish over white paper, the transmitted light gave a rosy hue approaching that produced on snow a few years ago by the auroral light. This residuum was again treated with water, and then with ammonia, which solved muriate of silver and also a brown yellow matter, giving the solution the appearance of a weak solution of geine. It appeared during some of these experiments, as if the nitric acid of nitrate of silver had acted very much like nitric acid and uric acid; but this is not essential to the proof of the presence of uric acid, and I omit this, merely alluding to it as a fact quite novel to me, and pass on to the educts by cold water from the coprolite. I had in my first trials, made a number of experiments on a portion of the coprolite remaining in one of my test tubes, which at the time I ran my pen through,

and made a marginal note in my journal, that probably the portion I was then operating upon had been used for testing the presence of sulphuric acid by barytes; for I found that even water, digested on it, produced a precipitate with sulphuric acid. On reviewing these experiments, and repeating them with your new samples, I find that this precipitate is *uric* acid, from the urate dissolved even by water. After the action of alcohol, water gives a perfectly colorless solution, which gave the following characters:

a. Evaporated, a white earthy crust, which easily *chars* by heat.

b. Sulphuric acid produced an immediate milkiness, and in the somewhat concentrated solution, a white precipitate, and as evaporation went on, needles—with all the appearance of sulphate of lime; some single, others with the peculiar star-like aggregation of that salt, but with those, distinct dots of a white earthy amorphous matter. Exposed to a gentle heat, these last blacken and darken, and then become white.

c. If the experiment is made with a larger portion of sulphuric acid and water, by careful evaporation, a white earthy, scaly precipitate occurs, but no appearance of needles in the acid liquor as before. This being neutralized by pure ammonia, and then the sulphate of ammonia being sublimed, the earthy precipitate *chars* without melting or turning white.

d. The watery solution evaporated dry, with nitric acid turns lemon yellow, and the yellow crust chars by heat.

e. Nitrate of silver produces a yellow brown precipitate, *insoluble in pure ammonia*, which, treated with nitric acid and evaporated to dryness, gave a *pinky* salt.

f. The precipitate by nitrate of silver, at a *heat far below redness*, is immediately decomposed and the *silver reduced.* What I had before suspected, became now in several trials perfectly distinct. A beautiful film and distinct globules of metallic silver were produced. This silver, &c. were treated with water to remove any nitrate of silver, and the metal again solved in nitric acid, produced all the characters of nitrate of silver. This easy reduction of nitrate of silver is a very distinctive character of uric acid, and forms one of the most exquisite examples of metallic reduction with which I am acquainted.

g. Phosphate and carbonate of soda produces in the watery solution an immediate and copious white precipitate. This is greater than could be due to a decomposed sulphate of lime, which exists in the solution, and is probably due to the decomposition of urate of ammonia, and the formation of less soluble urate of soda.

h. A portion of the watery solution being left to spontaneous evaporation, a creeping mass of dendritic crystals was obtained, partly soluble in a small quantity of water. This gave no indication of sulphuric acid by muriate of barytes. The crystals solved in nitric acid, but gave no indication of sulphuric acid by nitrate of barytes. The nitric solution, by evaporation and agitation, deposited crystals. They cannot be *phosphate* of lime therefore; and yet their solution in water is precipitated by oxalate of lime. I conclude they are in part *urate of lime.*

i. Whatever care be taken in filtering and evaporating the water of solution, the dry white crust with a tinge of yellow here and there, always solves with effervescence in dilute nitric acid. This may arise from the presence of soluble alkaline carbonates or carbonate of lime, produced by their action on a soluble salt of lime—or more probably, from the certain presence of uric acid, which may exist as a *bi-urate.* This effervescence is not confined to the bottom of the evaporating dish, where any carbonate of lime would be deposited, but is manifested in every part of the white crust, from the edge to the bottom of the dish. I have not, from want of material, pursued my inquiries so far on this residuum as is desirable. It is however abundantly evident, that it consists in part of soluble urates. It chars by gentle heat, its solution in water is precipitated by sulphuric acid, and this precipitate also chars; its habitudes with nitrate of silver, falling in yellow brown flocks, insoluble in pure ammonia, easily reduced to metallic silver by gentle heat, and producing a pinky salt when treated with nitric acid—all demonstrate the presence of uric acid.

I have attempted to estimate the quantity of urates present in the coprolite: here I find great difficulty, and we must be content with an approximation. From the amount of what I have considered only as muriate of soda, solved by alcohol, is to be deducted the small portion of urates which I have since found that solution to contain. My former estimate of 0·51 per cent. mu-

riate is therefore too high. The very small portion on which I have operated, has rendered the amount so solved impossible to estimate. But disregarding that, I find the coprolite yields to water as follows:—the first 15 grains being the experiment made with your first parcel, where yellow drops formed round the edge of the dish. I have not observed this in two subsequent trials, but only a yellow cast here and there in the crust. As this first trial yielded a much greater proportion to water than either of the others, I conclude that water and sulphate of lime are quite unequally distributed, even in the same sample. After several digestions in cold alcohol,

	Grs.	Per cent.	Per cent.
The first 15 grs. gave to boiling water,	0·30	=	2·0000
Second 30 grs. gave to cold water,	0·1545	= 0·5150	0·9443
And then afterwards, to boiling do.	·1288	= 0·4293	
Third 20 grs. gave to cold do.	·1545	= 0·7725	1·1613
And then afterwards, to boiling do.	·0777	= 0·3888	
			3)4·1056
			1·3685

the average solved by water.

If we now assume that taken up by cold water to be only urates, and that by boiling, sulphate of lime, setting its urate against the sulphate dissolved by cold, we have in 30 and 20 grains 0·5150+0·7725=1·2875 or 0·6437 per cent. Supposing this 0·6437 to exist as urate of ammonia, $\frac{1}{10}$ in round numbers would consist of that base, leaving for uric acid per cent. 0·5794 grains. You will observe therefore how much of the little you have been able to spare, has been used in quantitative examinations. My stock of coprolite had now reduced itself to the 20 grains last mentioned, and I felt desirous of ascertaining from the amount of precipitated urate of silver, the exact quantity of uric acid, and of making a more rigid quantitative examination of the other ingredients, as my former results were determined from a much less quantity. I had begun this analysis before being aware of the fact, that my alcohol, sp. gr. 0·832, had dissolved some urate. Finding therefore that I had lost the means of determining accurately the amount of chlorine and uric acid, I have abandoned the inquiry for the present. However, the

cold and hot water dissolved from the 20 grains =1·161 per cent. When the cold water solution was evaporated nearly dry, it was left to spontaneous evaporation over night. A beautiful mass of *white dots* were found, which were nearly all collections of pearly radiations, somewhat like aggregations of sulphate of alumina, surrounded by a distinct border, of which alone other dots were composed, that is, dotted with rings. The boiling water solution was evaporated on these dots, rings, and general white film, and then the whole treated with cold water. It was not all solved. A gray powder remained, soluble with effervescence in nitric acid, and this solution afforded by evaporation evidence of uric acid. The solution in cold water gave by nitrate of silver, first, universal yellowness, very soon succeeded by copious yellow brown flocks, which in mass appeared red brown. These were exposed to light for thirty six hours; but changed not their color. Being well washed, they were divided into two portions. The one gave, being heated on glass gently, metallic silver—a most beautiful example—evident to the eye at arm's length. The remaining portion of these brown flocks was treated with nitric acid and cautiously evaporated. It began to turn yellowish, and being so far evaporated as not to drop from the dish, that was inverted over a vessel of pure ammonia, whose vapor caused it to turn orange red, and then decidedly reddish by a little heat. It was then subjected to the action of ammonia, and reheated, when it became crimson, mottled with *purple*, no doubt purpurate of ammonia. It is not worth while to go into the quantitative analysis of your coprolite again. It is not a matter where atomic weight is to be settled, or the exact constitution of a mineral to be determined. Its ingredients doubtless vary even in some portions of the same mass. The result of the analysis which I have already sent you, is near enough to settle the question of the presence in this substance, of a large proportion of phosphate and carbonate of lime and magnesia. We have proof of the presence of uric acid, of muriate of soda, and of ammonia. The last exists probably as urate, triple phosphate, and possibly muriate. It may be said that I ought to have found ammonia in my solution of urates. I attempted so to do. The solution remaining above the flocks of urate of silver, if ammonia urate had existed, should contain nitrate of ammonia. It was evaporated dry—probably no nitrate

of ammonia was decomposed. The dry mass was scraped off and the powder dropped to the bottom of a test-tube and tested with a drop of caustic potash warmed, and a glass rod moistened with muriatic acid held at its mouth. These manipulations being almost simultaneous, no trace of ammonia appeared. I shall not convert my period into an exclamation point; for one would hardly expect such evidence of ammonia, if it there existed. I was operating on 20 grains only of coprolite, whose urate of ammonia, as has been already shown, was only 0·1545 grs., and its ammonia not quite 0·015 grs., a quantity quite too small to be estimated in this mode, or by a delicate nose.

[Dr. Dana did not attempt to draw any inference from the preceding results; but at my particular request, he undertook the following ingenious course of reasoning, in a letter dated December 8th, 1843.—E. H.]

I drew no inference from the facts detailed in my last letters, except that the substance I had examined was coprolite. The presence of urates would not conclusively prove it the excrements of birds. Uric acid is common to the droppings of birds and of reptiles. This acid and urates are always evacuated by birds, mixed with the feces, and by reptiles, sometimes accompanied by, but never mixed with, the fecal matter. The anatomical structure of the lungs, primæ viæ, and urinary organs of birds and reptiles, is not less strikingly analogous than their urinary secretions. While in reptiles this consists of uric acid almost pure, being in fact the urine only, evacuated as a soft solid, at long intervals of from three to six weeks, and in large serpents, in masses of from three to four ounces weight—the urine of birds is daily evacuated mixed with the feces.

These facts, taken in connection with our knowledge of its composition, will allow us to class your coprolite with the droppings of birds. Let us compare its composition with the droppings of reptiles and of carnivorous birds, which agree in containing like portions of uric acid. The earliest observations on the urine of lizards were by Schreibers, 1813. He was followed in 1815 by Dr. Prout, who examined the solid excrement of the boa constrictor and communicated his results to Dr. John Davy, on the eve of the latter's departure for Ceylon, in 1817. Dr. Davy there made extended observations on the anatomical structure and urinary excretions of serpents, lizards, turtles, and tortoises,

&c., the general result of which I have alluded to above. He proved that the solid excrement examined by Dr. Prout, was the urinary excretion only. The researches of Wollaston and Coindet have shown the closest relation between this and the droppings of carnivorous birds; while the analysis of hen's dung by Vauquelin, and the recent numerous analyses of guano, show too what might be expected to be the composition of the fecal matter of omnivorous birds, and the state to which it is reduced by time, as has been guano. Let us tabulate these analyses, to see at a glance their results.

	Uric acid.	Ammonia.	Earthy phosphate, alkaline phosphate, and carb. lime.	Alk. salts.	Org. mat.
Urine of lizards, several species, by Schreibers,	94·	2·	3·33 phos. lime.		
Boa constrictor, (Prout,)	90·16	1·70	·80 phos. and carb. lime.	6·10*	2.94

Davy gives us no proportional results; but he states the general fact, that the urine of all the reptiles he examined, is nearly allied to that of the boa constrictor in some cases, and in the alligator is mixed with a large portion of phosphate and carbonate of lime. Wollaston states that the excrement of the pelican is like that of the boa.

Carnivorous birds, (Coindet.)	Uric acid.	Ammonia.	Phos. lime.
American sea eagle,	84·45	9·20	6·15
" hunting eagle,	90·37	8·87	·76
" duke of Virginia,	88·71	8·55	2·74
Senegal eagle,	89·79	7·85	2·36

One is impressed at once with the difference between these droppings; those of reptiles being nearly pure uric acid, and those of carnivorous birds pure urate of ammonia. If now we suppose the urine of lizards to be placed in a state most favorable for the complete decomposition of its uric acid, we should have that element removed. There will remain urate of ammonia and phosphate of lime—a compound wholly unlike your coprolite. If we suppose that by time and exposure the urine of the boa loses its urates, then we have left, phosphates, sulphates, chlorides, and a trace of carbonate of lime, substances found in your coprolite also. But the proportions of these are not only very different, but a large proportion of potash should

* Potash and traces of common salt, 3·45.

remain, no trace of which was found in your coprolite. It seems not very probable that this salt should have been wholly removed as a soluble urate, while more soluble salts, chlorides and sulphates, have remained. Let it be supposed that your coprolite has been dropped by a purely carnivorous bird. The uric acid here exists as a urate or muriate of ammonia. If all this is removed, we have left only phosphate of lime, wholly unlike your coprolite. There are therefore two considerations which will not allow us to class that substance with the droppings of reptiles, or of purely carnivorous birds. The first is founded on their chemical composition; the second is founded on the great improbability of such droppings having been so placed as to allow the almost complete disappearance of even the urate of ammonia. The most probable supposition, had that been the case, would be, that your coprolite was dropped by an alligator, the urine of that animal, according to Davy, containing the largest proportion of phosphate and carbonate of lime.

It is not probable that your coprolite has been more favorably placed than guano, for the removal of its uric acid and urates. If now we look at the composition of guano, no substance claiming a common origin varies more in its composition. From Klaproth, who first analyzed it, to Bartels, whose analysis is the last I have seen, we find that guano presents a mass of birds' droppings in various states of decomposition, and various salts, the result of that process. If we compare your coprolite with the results of Prof. Johnston's examination, it will appear to have undergone in its uric acid, not far from a similar amount of change, and a more perfect removal of its urates and soluble salts. The small portion of uric acid found by Prof. J. has a direct bearing on this question. That even guano is not the product of birds feeding only on fish, is evident from a comparison of its composition with that of the droppings of the sea eagle. No decomposition of that would afford the results presented by guano. Let us tabulate the results of the analysis of that substance.*

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* For more recent analyses of guano, see the subsequent pages of this volume, where the results of Mr. E. F. Teschemacher and Mr. Dunham Smith will be given.—Eds.

	Klaproth.	Fourcroy and Vauquelin.	Vœlkel.	Bartels.	Johnston. 2 analyses. 1st.	Johnston. 2 analyses. 2d.	Ure.	Anonymous.
Urate of ammonia,	16·	9·	9·	3·24				
Uric acid,					0·	0·8		15·
Ammonia,					0·	7·		15·
Oxalate of ammonia,		10·6	10·6	13·35				
" lime,	12·75	7·	7·	16·36				
Phosphate of ammonia,		6·	6·	6·45			oxalate included. 13·	
Phosphate of lime,	10·	14·3	14·3	9·94	with some carb. lime. 44·	29·3	25·	30½
" ammonia and mag.,		2·6	2·6	4·19				
" soda,				5·29				
Muriate of soda,	0·5			0·10	32·1	11·4		
Sulphuret of soda,		3·3	3·8	1·19				
" potash,		5·5	5·5	4·22				3·
Muriate of ammonia,		4·2	4·2	6·50				
Clay and sand,	32·	4·7	4·7	5·90			1 from birds' crops.	
Water and organic matter,	28·75	32·3	32·3	28·31	23·5	51·5	61·*	36½

The samples examined by Dr. Ure were the purest guano furnished by the governments of Peru and Bolivia. Casting the eye over all these results, we draw two inferences: 1st. If your coprolite had been the excrement of a reptile, it must have been placed in peculiar circumstances to have had its uric acid so fully removed. If removed, it has left a compound more nearly resembling that of guano. This is decisive. 2d. It is seen from Prof. Johnston's results, that it is possible to have all the uric acid removed in one case, and 0·8 only remaining in another, leaving phosphate not differing much in its proportions from that found in your coprolite.

If we recur with these facts in mind to your coprolite, and bear in mind its urates, phosphates of lime and magnesia, carbonate of lime, sulphates, muriates, and organic matter, volatilized at a red heat, and silicates, the conclusion seems inevitable, that it has been dropped by a bird belonging to the class which has deposited the beds of guano.†

* Including urate of ammonia, and 11 water.

† Within a few weeks my attention was called by reading an article in the London Mech. Mag. to a paper by MM. Girardin and Preisser on fossil bones, which I have since read in Ann. de Chimie for November, 1843. At page 370 is the following account of the results of an examination of the coprolite of an Ichthyosaurus from Lyme Regis, Eng. The ingredients are stated in the order of their greatest amount. Subphosphate of lime, (much); carbonate of lime; urate of ammonia; urate of lime; silica; oxalate of lime, (small); alkaline sulphates; fish scales. S. L. D.

October 23d, 1844.

ART. VI.—*Extract of a Letter from Prof. E. Hitchcock, embracing miscellaneous Remarks upon Fossil Footmarks, the Lincolnite, &c., and a Letter from Professor Richard Owen, on the great Birds' Nests of New Holland.*

TO THE EDITORS.

SINCE you have published in your Journal the account by Cook and Flinders, of the great bird nests found by them in New Holland, it strikes me that your readers will be glad to see the opinion of one so eminently qualified to judge concerning them as Prof. Owen. I therefore copy the following letter from him on the subject, lately received; and not the less willingly, because his opinion is adverse to the suggestions which I made, (I cannot say adverse to my *opinion*, since I had not made up my belief fully,) that they might be the nest of the Dinornis; for truth should be the grand object in view, rather than support to one's own notions.

College of Surgeons, London, August 30, 1844.

Dear Sir—I beg to acknowledge your friendly letter of the 23d of July, which has just reached me. I have long been aware of the notice of the large birds' nests, by Cook and Flinders. Sir Robert Inglis was kind enough to write out an account of them for me, soon after my first suspicions of a bird of extraordinary stature in New Zealand, had been excited by the fragment of bone, which I afterwards described in the Zoological Transactions, in 1839. Independently, however, of the different locality of the nests, Mr. Gould's interesting description, in the "Birds of Australia," of the enormous ones built in common, by the *Dalagella* or brush turkey of Australia, and by the *Megapodius*, warns us of the danger of inferring too absolutely, the size of a bird from that of its nest.

Nests constructed as Cook and Flinders describe, cannot resist the action of the elements many years, unless annually repaired. It would be a very extreme hypothesis, to suppose the nests, seen by the circumnavigators, to have been the enduring evidence of extinct species; but say that they were of comparatively recent construction, and the work of existing species, if such species were terrestrial, brevipennate birds, of a bulk proportioned to the

nests, it is so improbable that such should have escaped observation, that I have come to the conclusion, that the great nests seen by Cook and Flinders, belonged to some aquatic birds; and at all events, are too remotely related to the discovery of the great Ornitholites of New Zealand, to merit notice in a rigid scientific attempt to reconstruct the lost feathered giants of that island.

I have forwarded by Messrs. Wiley & Putnam, booksellers, a copy of my paper on Dinornis, to my respected correspondent, Prof. Silliman; and a copy by a private opportunity, to yourself. Your beautiful discovery of the Ornithichnites has always been in my thoughts, while working out the New Zealand bones. I earnestly hope that you may be successful in obtaining some characteristic fossils from the same sandstone.

Dr. Dana's skilful analysis has yielded a beautiful and most unexpected corroboration of the accuracy of your original deductions of the class of animals to which the footprints belonged. We must bear in mind, however, that in all the Ovipara, in the Cloaca, the urine blends with the excrement.

I remain very truly yours, RICHARD OWEN.

I hope you will give your readers, ere long, some account of Prof. Owen's paper on the Dinornis.* It is certainly the most sagacious and beautiful example of reasoning in comparative anatomy, that has ever fallen under my notice; and impresses us deeply with the marvellous, and yet mathematically accurate character of that curious science. The supposed connection between the extinction of the Dinornis, and the introduction of cannibalism into New Zealand, is very interesting in a moral point of view.

The fact quoted by Mr. Owen from Mr. Darwin, that no mammal, except a small rat, exists in New Zealand, which is more than seven hundred miles long, may perhaps show us why we have not yet found the remains of any vertebral animal (with one or two exceptions) in the sandstone of the Connecticut valley; although birds, allied to the Dinornis, must have been very numerous.

From the locality of footmarks in Northampton I have recently obtained a slab, considerably broken indeed, which exhib-

* An abstract of this paper may be looked for in the Bibliographical Notices of this number.—EDS.

its in relief three tracks of the huge *Ornithoidichnites giganteus;* the right and left feet being distinctly marked by the phalangeal protuberances of the toes. Between the first and second tracks, the stride is fifty-five inches; and between the second and third, fifty-one inches; which, although longer than usual, is considerably less than I have seen at the same locality. The track, also, is about nineteen inches long, and twelve inches between the tips of the outer toes, and six and a half wide behind; whereas, the specimen from the same locality, figured in the American Journal of Science for January, 1836, was seventeen inches long, and ten inches between the tips of the toes, and four inches and eight tenths wide behind. And upon the whole, I incline to believe that the present example was made by a larger foot than the former one.* But I ought to give a caution on this subject. The fact is, there is danger of overestimating the size of these larger tracks; especially those that are depressions. The rock is a shaly sandstone, splitting off in fine layers, especially after much exposure to the air, or the floods of Connecticut River; and as the depression often extends through many layers, the difficulty is, to know on which of them the animal originally trod. If we get below that layer, the track will be too large; for it is easy to see, that as we descend below the surface originally trod upon, the curvature of the layers will be less in depth, but broader. Even the length of the track may, in this way, be somewhat increased; chiefly, however, at the heel. I have a specimen from that locality, in which the toes are nearly four inches wide; (No. 42.) Another specimen (No. 128) requires four quarts of water to fill it. A drawing of such specimens would have an imposing effect; but it would be very likely to prove an exaggeration; even though the exact form of every part of the foot be presented. I have noticed, however, that the mud, which filled the track, is usually more or less concreted, and less slaty than the surface on which the track was made; and, therefore, I have thought it safer to get the dimensions from a track in relief, of this description, than from a mould. Such was the character of the specimen, figured in your Journal. Even though I might have found tracks at the same locality

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* Not long ago I obtained from a locality in Springfield a track in relief of the remarkable *Sauroidichnites polemarchius,* which is fifteen inches long; one inch longer than that figured in my Final Report.

somewhat larger, (and I incline to the opinion, that some of them are really from eighteen to twenty inches long,) yet I preferred to give one, about which there could be no doubt; and I choose to have it fall short of, rather than exceed, the truth. Allow me to add, that the track figured in your Journal, was the first one I ever discovered of this giant species; and I well recollect how I was on the point of rejecting it, because it seemed impossible that it could be a real track. I ought not, therefore, to be surprised at the great scepticism manifested by so many, who had only a drawing to look at.

There is another circumstance that would make the track of the same bird longer or shorter, according to the depth to which its foot sunk in the mud. I have never seen a specimen of this species, in which a distinct impression of the distal extremity of the tarso-metatarsal bone exists. But the cushion beneath the distal end of the proximal phalanges, sloped backwards in such a way, that the deeper the foot sunk, the longer would be the track. In the specimen figured in your Journal, the depth of the impression was not very great; so that perhaps the very next step might have been somewhat longer.

But to turn to another subject. I feel really in doubt whether to say any thing farther about the Lincolnite, since the mineral is so small, and so rare, as hardly to be worth any farther discussion. Allow me, however, to express the belief, that your note, appended to my statement in the last number of the Journal, does not settle the question; as I think I could satisfy you, were it in my power to send you specimens. For the modifying plane, which you suppose Prof. Shepard has mistaken for a primary plane, I have never noticed, except in two or three instances; and then it was so very narrow, (much more so than the figure in my Final Report,) as to be visible only by a good glass; and it could not, therefore, have been confounded with the primary planes, by so practised an observer as that gentleman.* I shall be surprised if he does not confirm this statement. Nearly all

* The plane ĕ (*f* in Phillips's figure) enlarged, may obliterate M, one of the lateral *primary* faces, or reduce it to a narrow plane, resembling the ĕ in common crystals of Heulandite; in this case the crystal would still be a right-oblique angled (right rhomboidal) prism, with M (if present) a narrow plane replacing a lateral edge. This narrow plane we have supposed to be the one above alluded to in the crystals of Lincolnite.—Eds.

the crystals which I have examined, stand out distinct and alone; and are most obviously, a right oblique angled prism, unmodified.

I have recently received a letter from Mr. Teschemacher, from which it appears doubtful whether he has ever measured any crystals of Lincolnite. He says, "Without intending to cast even the imputation of error on Mr. Alger's statement, I must say, that of my own knowledge, I never measured Lincolnite. Mr. Alger sent me a small parcel of crystals of Beaumontite, for measurement, with a view of ascertaining their identity with Heulandite; several of which I measured and found the angles agree. Among them was a single crystal, wrapped in paper, which I believe I also measured. Mr. Alger says now, that this was a crystal of Lincolnite. He at various times made inquiries of me, respecting my opinions of the identity of both Lincolnite and Beaumontite with Heulandite, which I freely gave him, and entered into various particulars on the subject; but he never gave me the slightest reason to imagine that he was writing a paper on the subject, for publication, in which these would be embodied and my name used, or I should have been more cautious. You must be well aware, that under these circumstances, I cannot allow my name to be used as deciding the point in question, without further investigation. And I think it right, therefore, to put you in possession of the facts.

"I might, and believe truly that I did, measure the crystal; but I know that I measured several, from which, owing to the small size of the modifying planes, the peculiarity of the light, &c., I could draw no satisfactory conclusion; and which I put away, selecting others which could be more easily measured. This single crystal was probably one of these; for supposing it Beaumontite, I did not pay the attention to it I should have done, had it been sent to me as Lincolnite."

In view of the above facts, you will pardon me for believing, that the claims of Lincolnite to be regarded as a distinct species, have not yet been set aside. But as I am almost entirely destitute of specimens, I fear that little farther progress will be made on the subject, unless some one has more time and zeal than I have, to explore the localities anew.

Amherst College, Oct. 25th, 1844.

ART. VII.—*On Pseudomorphous Minerals*, [Die Pseudomorphosen des Mineralreichs;] by Dr. J. REINHARD BLUM. 8vo, pp. 378. Stuttgard, 1843.

MINERAL Pseudomorphism is usually considered a curious branch of science, possessing little of that general interest which really attaches to it. The instances of alteration occurring in rocks are often looked upon as confined to isolated crystals, arising from some accidental cause of limited influence. But the developments of the few past years lead us to believe that Pseudomorphism will soon constitute one of the most important chapters in geological treatises.

The elaborate work by Dr. Blum has prepared the way for more enlarged views on this subject, and opens some insight into this obscure branch of the chemistry of nature. His facts are detailed with great fullness, and show thorough research. All geognostic information bearing upon the origin of these pseudomorphs is added by him as far as ascertained; and in addition, the nature of the chemical changes undergone is discussed, and various causes suggested for the production of these singular mineral metamorphoses.

Dr. Blum divides all Pseudomorphs into two classes:—

I. Pseudomorphs produced by a partial change in the composition of the original mineral.

II. Pseudomorphs produced by a complete displacement of the original mineral by another.

In the *first* class, one or more elements are *removed*, *added*, or *introduced by substitution*;—and these *three* modes constitute *three divisions* of this class of Pseudomorphs. As an example of the *first* of these subdivisions we instance Gay-Lussite changed to calc spar by the *removal* of carbonate of soda and water; the *second*, anhydrite, changed to gypsum by the *addition* of water; the *third*, gypsum changed to calc spar, by the *substitution* of sulphuric acid for carbonic acid.

In the *second* class, to form the pseudomorph, the original mineral is wholly removed and replaced by another.

The following catalogue contains the various examples enumerated by Dr. Blum of these different kinds of Pseudomorphs.

Class I.

Subdivision 1.

Pseudomorph.	Form imitated.
Calc spar,	Gay-Lussite.
Kyanite,	Andalusite.
Steatite,	Hornblende.
Native Copper,	Red Copper Ore.
Vitreous Silver,	Red Silver Ore.

Subdivision 2.

Gypsum,	Anhydrite.
Mica,	Pinite.
Antimony Bloom,	Native Antimony.
Anglesite,	Galena.
Specular Iron,	Magnetic Iron.
Brown Iron ore,	Specular Iron.
Malachite,	Red Copper ore.
Variegated Copper ore,	Vitreous Copper.
Copper Pyrites,	Vitreous Copper.

Subdivision 3.

Heavy spar,	Witherite, Baryto-calcite, and Calc spar.
Calc spar,	Gypsum.
Dolomite,	Calc spar.
Chalcedony,	Datholite.
Jasper,	Hornblende.
Opal,	Augite.
Quartz,	Garnet.
Cimolite,	Augite.
Lithomarge,	Topaz, Feldspar.
Kaolin,	Feldspar, Porcelain spar, Leucite.
Mica,	Andalusite, Wernerite, Tourmaline.
Prehnite,	Analcime, Leonhardite.
Talc,	Kyanite, Feldspar, Pyrope.
Steatite,	Dolomite, Spinel, Quartz, Andalusite, Topaz, Feldspar, Mica, Wernerite, Tourmaline, Staurotide, Garnet, Idocrase, Augite.
Serpentine,	Augite, Hornblende, Chrysolite.
Chlorite,	Garnet, Hornblende.
Hornblende,	Augite.
Green earth,	Augite.
Pyrolusite,	Manganite.
Hausmannite,	Manganite.

Pseudomorph.	Form imitated.
Antimony Bloom,	Gray Antimony.
Antimony Ochre,	Gray Antimony.
Antimony Blende,	Gray Antimony.
Bismuth Ochre,	Needle Ore.
Minium,	Galena, White Lead ore.
Pyromorphite,	Galena, White Lead ore.
White Lead ore,	Galena, Anglesite, Leadhillite.
Molybdate of Lead,	Galena.
Red Iron ore,	Pyrites, Cube ore, Spathic Iron.
Brown Iron ore,	Ankerite, Pyrites, White Iron Pyrites, Scorodite, Cube ore, Spathic Iron.
Göthite,	Pyrites.
Pyrites,	Mispickel.
Green Vitriol,	Pyrites.
Pseudotriplite,	Triphyline.
Wolfram,	Scheelite.
Cobalt Bloom,	Smaltine.
Black Copper,	Vitreous Copper.
Malachite,	Azurite, Copper Pyrites.
Chrysocolla,	Copper Mica and Red Copper ore.
	CLASS II.
Common Salt,	Dolomite.
Anhydrite,	Common Salt.
Gypsum,	Common Salt.
Polyhalite,	Common Salt.
Carbonate of Strontian,	Gypsum.
Quartz,	Heavy spar, Fluor spar, Gypsum, Calc spar, Baryto-calcite, Dolomite, Scheelite, Galena, White Lead ore, Specular iron, Pyrites, Spathic iron:—as *Prase*, Calc spar:—as *Chalcedony*, Heavy spar, Fluor spar, Calc spar, Dolomite, Pyromorphite:—as *Carnelian*, Calc spar:—as *Hornstone*, Fluor spar, Calc spar, Mica, Spathic iron:—as *Semiopal*, Calc spar.
Lithomarge,	Fluor spar.
Feldspar,	Calc spar.
Meerschaum,	Calc spar.
Pyrolusite,	Calc spar.
Hausmannite,	Calc spar.
Manganite,	Calc spar.
Psilomelane,	Heavy spar, Fluor spar, Cube ore.
Calamine,	Fluor spar, Calc spar.

Pseudomorph.	Form imitated.
Electric Calamine,	Fluor spar, Calc spar, Dolomite, Galena, Pyromorphite.
Tin ore,	Feldspar.
White Lead ore,	Heavy spar, Fluor spar.
Peroxyd of Iron,	Fluor spar, Calc spar.
Brown Iron ore,	Heavy spar, Fluor spar, Calc spar, Dolomite, Quartz, Comptonite, Blende, Galena, Pyromorphite, White Lead ore, Red Copper ore.
Pyrites,	Heavy spar, Calc spar, Quartz, Brittle Silver ore, Red Silver ore.
White Iron Pyrites,	Brittle Silver ore.
Spathic Iron,	Calc spar, Dolomite.
Malachite,	Calc spar, White Lead ore.
Chrysocolla,	White Lead ore.

To this catalogue we may add the following:—

Green earth under the form of Haydenite.

Chlorophyllite and Fahlunite under the form of Iolite.

Rensselaerite under the form of Augite.*

Pseudomorphous changes in the simple salts, produced by a replacement of the acid or base, admit of easy explanation upon the most common principles of chemistry. Such is the change of carbonate of lime to sulphate of lime (gypsum) by the expulsion of the weaker acid (carbonic) by *sulphuric acid*, and we need only look to some decomposing pyrites (sulphuret of iron) for a source of this acid. Other changes are more difficult of explanation. We propose to run over the most important facts in Dr. Blum's work, as a basis for some farther remarks upon the causes of pseudomorphism, its extent and geological bearing. We take the book in course, and extract such facts as appear of special interest, even if before published, as this subject is not systematically treated in any work in our language. Haidinger's very valuable article on this subject, in volumes IX and X of Brewster's Edinburgh Journal, is the only one of much importance to which we can point.

Gypsum with the form of Anhydrite.—Large deposits of anhydrite have undergone this change to gypsum. In the Canaria

* Another class of Pseudomorphs not particularly distinguished, includes those which proceed from the change of one form of a dimorphous substance to another. Arragonite thus changes to Calc spar without losing its prismatic form.

Thal, a bed of this mineral in mica slate consists of gypsum wherever it is exposed. At Bex in Switzerland the same fact is observed; the unaltered anhydrite is invariably obtained by digging down sixty or one hundred feet from the surface. The same has been observed by Alberti in the muschelkalk of Germany. This change consists merely in the addition of water, and the facts cited evince that it takes place principally through atmospheric agency.

Chalcedony with the form of Datholite.—According to Levy the crystallized chalcedony from Hay-Tor, Devonshire, called Haytorite, is altered Datholite. The change consists in the removal, from the compound, of lime, boracic acid, and water, and the addition of silica.

Cimolite with the form of Augite.—These pseudomorphs occur near Bilin in gneiss along with kaolin, silver-white mica and quartz, and the basalt near by is changed to a clayey rock. The gneiss when unaltered contains brown mica and fresh crystals of augite. Rammelsberg's analysis gives the formula $\dddot{\mathbf{Al}}\,\dddot{Si}^3+3\dot{\mathbf{H}}$, which is identical with that of Cimolite. The specific gravity *after* alteration is 2·21 or less; *before*, 3·3. Three atoms of the original augite, $3\dot{R}^3\,\dddot{Si}^2$, with $6\dot{\mathbf{H}}$, would make, on substituting $\dddot{\mathbf{Al}}^2$ for the bases, $2(\dddot{\mathbf{Al}}\,\dddot{Si}^3+3\dot{\mathbf{H}})$, or 2 atoms of Cimolite. Dr. Blum suggests that carbonic acid may have been the agent that carried off the lime, yet remarks that no trace of carbonate of lime has been found in the rock.

Lithomarge with the form of Topaz.—Topaz altered to lithomarge occasionally occurs in Brazil in a talcose slate, and a Siberian specimen has been observed with a milk white exterior, owing to a similar change. The change consists in the removal of fluorid of aluminium and the addition of water.

Lithomarge with the form of Feldspar.—Numerous instances of this change are cited by Dr. Blum. In explanation of it, it is stated, that from the feldspar, $(\dot{K}\,\dddot{Si}+\dddot{\mathbf{Al}}\,\dddot{Si}^3,)$ $\dot{K}\,\dddot{Si}$ is removed, and $\dot{\mathbf{H}}$, (or water,) added. Carbonated water is supposed to be the principal agent in effecting this change.

Kaolin with the form of Feldspar.—This very frequent change requires only the most common agents. Forchhammer has shown that heated water, even when pure, will cause the altera-

tion; but Dr. Blum is disposed to consider carbonic acid as usually present when it is in progress, and alludes to instances of regions of carbonated waters where the process goes on with unusual rapidity.

The formula for 3 atoms of feldspar is $\dddot{\mathbf{Al}}^3\,\dddot{Si}^9+\dot{K}^3\,\dddot{Si}^3$, or summing up, $\mathbf{Al}^3\,\dot{K}^3\,\dddot{Si}^{12}$. Remove now $\dot{K}^3\,\dddot{Si}^3$, and it leaves $\dddot{\mathbf{Al}}^3\,\dddot{Si}^4$, which is the composition of kaolin, except that $6\dot{\mathbf{H}}$ is added.

Kaolin with the form of Porcelain Spar.—At Obernzell, according to Fuchs, kaolin is largely derived from porcelain spar. This mineral occurs in granite, along with opal and semiopal, in incrusting and nodular masses. This opal is believed to have proceeded from the silica liberated during the process. From $3[4\dot{Ca}\,\dddot{Si}+4\dddot{\mathbf{Al}}\,\dddot{Si}+\text{Na}\,\mathbf{Cl}]$, $12\dot{Ca}$, $8\dddot{Si}$, $3\text{Na}\,\mathbf{Cl}$ pass off, probably by the action of carbonated waters, and $24\dot{\mathbf{H}}$ is added; making $4[\dddot{\mathbf{Al}}^3\,\dddot{Si}^4+6\dot{\mathbf{H}}]$, or 4 atoms of kaolin.

Kaolin with the form of Leucite.—This change consists simply in the removal of the potash, $\dot{K}^3$, from $\dot{K}^3\,\dddot{Si}^2+3\dddot{\mathbf{Al}}\,\dddot{Si}^2$ (leucite) and the addition of $6\dot{\mathbf{H}}$, making thus $\dddot{\mathbf{Al}}^3\,\dddot{Si}^4+6\dot{\mathbf{H}}$.

Mica with the form of Andalusite.—Crystals of Andalusite have been observed changed wholly to a light colored mica, and others in which this change was but partially complete, the ends being mica and the middle Andalusite. In the change, silica and potash are added.

Mica with the form of Scapolite.—Dr. Blum describes a crystal of scapolite altered to mica, from Arendal, which is three inches long, and consists of an aggregate of mica scales. Along with the altered scapolite there is a soft talc-like mass, which also appears to have been produced by the alteration of this mineral. To form the mica Dr. Blum supposes $4[\dot{Ca}^3\,\dddot{Si}+3\dddot{\mathbf{Al}}\,\dddot{Si}]$ (4 of scapolite) to have lost $\dddot{Si}$, $12\dot{Ca}$, and received $3\dot{K}$, whence would proceed $3[\dot{K}\,\dddot{Si}+4(\dddot{\mathbf{Al}},\dddot{\mathbf{Fe}})\dddot{Si}]$, or 3 atoms of mica. Yet as the exact composition of the particular mica is not known, there is some doubt of the correctness of this view.

Mica with the form of Tourmaline.—Crystals of tourmaline consisting of mica or with mica terminations have been observed

in Saxony, at Heidelberg, near Rozena, and elsewhere. That at Rozena is a red tourmaline, altered to lepidolite or reddish mica. The Micarelle or Micanite of Neustadt is shown by Dr. Blum to be altered tourmaline, some of the crystals having distinctly the form of that mineral.

Prehnite with the form of Analcime—These pseudomorphs occur at Dumbarton, at Molignon in the Tyrol, and near Wolfstein in the district of the Lower Rhine. At the last locality they are associated with calc spar and Datholite in Diorite. The Datholite appears to have been partially acted upon at the time of the change, and is supposed to have given the lime to the forming Prehnite. The change requires $\dot{Na}^3 \dddot{Si}^2 + 3\dddot{\mathbf{Al}}\dddot{Si}^2 + 6\dot{\mathbf{H}}$ (analcime) to have lost $3\dot{Na}, 2\dddot{Si}, 3\dot{\mathbf{H}}$, and received $6\dot{Ca}$, by which resulted $3[\dot{Ca}^2 \dddot{Si} + \dddot{\mathbf{Al}}\dddot{Si} + \dot{\mathbf{H}}]$, or 3 atoms of Prehnite.

Talc with the form of Kyanite.—These pseudomorphs have been observed at Wustuben, in the Fichtelgebirge. The edges of the crystals are rounded and the surface is covered with a thin crust of talc; within they are a fine-grained aggregate of talc, possessing the softness and other characters of this mineral. The change consists in the substitution of magnesia for alumina.* According to Dr. Blum, $2[\dddot{\mathbf{Al}}^2 \dddot{Si}]$ loses $4\dddot{\mathbf{Al}}$, and receives $3\dot{Mg}$, and becomes thus $\dot{Mg}^3 \dddot{Si}^2$.

Talc with the form of Feldspar.—This pseudomorph has been found at the tin mines of Altenberg in Saxony, associated with quartz, specular iron, and light colored talc. The feldspar crystals consist of talc in fine foliated grains; they have a rough drusy surface, yet tolerably sharp edges. The change consists in substituting $6\dot{Mg}$ for $\dot{K}, \dddot{\mathbf{Al}}$, thus altering $\dot{K}\dddot{Si} + \dddot{\mathbf{Al}}\dddot{Si}^3$ to $2[\dot{Mg}^3 \dddot{Si}^2]$, or 2 of talc.

Steatite with the form of Hornblende.—The Pargasite occurring in granular limestone at Pargas, Finland, is sometimes altered to steatite of a greenish color. From the nature of the crystals, Dr. Blum infers that the change commenced at the centre, where it is most complete. It requires the removal only of the

* The latest analyses make talc and speckstein (steatite) identical in composition, and lead to $\dot{Mg}\dddot{Si}$ as the formula of both.

lime; $\dot{C}a\,\dddot{S}i + \dot{M}g^3\,\dddot{S}i^2$ (Pargasite) dropping $\dot{C}a$, thus becomes $3[\dot{M}g\,\dddot{S}i]$.

Steatite with the form of Dolomite.—These rhombohedral pseudomorphs are found at Göpfersgrün. The change to steatite is seen more or less complete also in the massive Dolomite. Marlboro', Vt. is another locality of steatitic crystals of Dolomite. Dolomite consists of carbonate of lime and carbonate of magnesia. The change consists in removing the lime and carbonic acid, and substituting silica.

Steatite with the form of Spinel.—This is a frequent pseudomorph in the granular limestone of Sussex County, N. J. and Orange County, N. Y. In some crystals the change is incomplete, while others appear to be wholly altered to steatite. Those of Newton, N. J. have a yellowish white or pale greenish color.* The Tyrol near Dualta la Toja has afforded specimens of *steatitic Pleonaste.* The change here is a simple substitution of silica for alumina; thus $\dot{M}g\,\dddot{\mathbf{Al}}$ becomes $\dot{M}g\,\dddot{S}i$.

Steatite with the form of Quartz.—These pseudomorphs occur at the same place at Göpfersgrün that affords the bitter spar crystals above noticed. The form and striæ of the planes are well preserved. Where the change is partial, the quartz has become white and without lustre; when complete, all the characteristics of the quartz are lost except the external form, and a soft earthy steatite has taken its place.

Dr. Marx has suggested that the magnesia that caused the change came from the bitter spar; but Dr. Blum urges in opposition to this view, that the magnesia in this mineral is in small quantities and still remains in the bitter spar pseudomorphs, and inclines to the opinion on the contrary that the quartz afforded the silica that has altered the bitter spar. Several instances are referred to of massive and columnar quartz in the same region altered to steatite, and also foliated quartz interlaminated with steatite in consequence of a partial change. The striæ of the surface still retained show that the whole was originally quartz.

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* Prof. Beck in his report on the Mineralogy of New York describes the Warwick crystals as black like spinels,—yet soft so as to be easily cut with a knife. His analyses show that part of the spinel still remains.

At Göpfersgrün the gangue is a steatitic slate, lying between mica slate below, and probably granular limestone or Dolomite above; and there is every reason to believe that the steatitic rock is an altered mica slate. After passing through twenty four to thirty feet of the decomposed slate of the surface, the steatite first appears, and continues for fifty or sixty feet: below this the pseudomorphous quartz and bitter spar are obtained both in crystals and massive. Near by this, the mica slate becomes penetrated with granular limestone. At Hohlenbrunn the same granular limestone contains, besides masses of quartz, octahedrons of fluor spar. These facts are urged by Dr. Blum as evidence that the same process which produced the steatitic pseudomorphs, changed the rock containing them from a mica slate. The steatite replacing the quartz is quite pure, while that of the slate is brown and impure from the iron in the mica, and looks like a clay slate.

The serpentine of Monte Rosa affords similar pseudomorphs. Dr. Blum describes a geode in his collection in which the terminal angles are steatite, and the exterior of the crystals has become yellowish-white or brownish-red, without affecting the sharpness of the edges or smoothness of the surfaces. The specimen is from Olmutschen in Mähren.

Similar crystals have been found by Prof. Emmons in the serpentine of Middlefield, Mass., and by Dr. Fowler in the granular limestone of Newton, N. J.

Pimelite is supposed by Dr. Blum to have often originated by similar changes, and also meerschaum in many instances. Nodules of meerschaum at Hrubschnitz, in serpentine, have often he states a nucleus of *firestone*, (a coarse kind of opal, occurring there in similarly shaped nodules,) while others are wholly meerschaum. Dr. Blum suggests that the silica that has passed off in the change is found in the opal that occurs at the same locality, and finds proof of this in the forms and position of the opal.

Steatite with the form of Andalusite.—Pseudomorphs of this kind have been described by von Leonhard and Goldfuss and Bishof. The change is a simple replacement of the alumina by magnesia.

Steatite with the form of Topaz.—The gneiss of Ehrenfriedersdorff, including with the tin ore and quartz, talc, lithomarge,

fluor spar, mispickel, and wolfram, contains also steatitic topazes engaged in quartz, part of which quartz is similarly altered to steatite. The change commenced with the exterior. In one crystal seen both ends are partially altered, while the middle retained its usual transparency and hardness. The *pycnite* of Zinnwald, Bohemia, is often changed to a greenish steatite.

The change of the topaz requires the removal of $7\dddot{\mathbf{Al}}$, $2\mathbf{Al}\,\mathbf{F}l^3$, and the addition of $6\dot{M}g$, by which $(\dddot{\mathbf{Al}}+2\mathbf{Al}\,\mathbf{F}l^3)+6\dddot{\mathbf{Al}}\,\dddot{Si}$ (topaz), becomes $6[\dot{M}g\,\dddot{Si}]$ or 6 of steatite.

Steatite with the form of Feldspar.—Several localities are stated, as Karlsbad in porphyry, Ehrenfriedersdorff in granite along with lithomarge pseudomorphs of the same mineral; near Thiersheim in granite, with steatitic pseudomorphs of quartz. In the change, $\dot{K}\,\dddot{Si}+\dddot{\mathbf{Al}}\,\dddot{Si}^3$ (feldspar) loses its potash and alumina and receives $4\dot{M}g$, making $4[\dot{M}g\,\dddot{Si}]$.

Steatite with the form of Mica.—At Monzoni, tabular crystals of mica changed to steatite occur along with steatitic spinels. At Brünn, the same occurs in a granite rock, the whole of which is much altered—the feldspar to kaolin, and the brown mica to a yellowish green steatite. The Thiersheim granite affords similar changes.

The *rubellan* from a wacke in Bohemia, is considered by Dr. Blum a mica altered to a reddish brown steatitic substance.

Steatite with the form of Scapolite.—The granular limestone of Ersby and Pargas abroad, and Newton, New Jersey, have afforded these pseudomorphs. The change consists in removing from $\dot{C}a^3\,\dddot{Si}+3\dddot{\mathbf{Al}}\,\dddot{Si}$ (scapolite), $3\dot{C}a$, $3\dddot{\mathbf{Al}}$, and adding $4\dot{M}g$, thus producing $4\dot{M}g\,\dddot{Si}$.

Steatite with the form of Augite.—Several localities are given of these pseudomorphs in wacke, basalt, or porphyry, among which are Eybenstock, Lützelberg in the Kaiserstuhl, and Pozza in the Tyrol. The crystals sometimes contain unaltered augite within. In the Fassa valley, the variety *Fassaite* occurs altered to steatite. Near Bilin in Bohemia, altered pyroxene is found in gneiss.

The *Rensselaerite* of Prof. Emmons is an interesting instance of this change in northern New York, where it forms extensive beds.

Much that is interesting might be cited respecting the steatitic pseudomorphs of tourmaline, staurotide, garnet and idocrase; but we pass on to the serpentine pseudomorphs.

Serpentine with the form of Augite.—Near Schwarzenberg in Saxony, a serpentine occurs with the form of Sahlite, which was taken for crystallized serpentine, until aftewards shown to have the angles of the latter mineral. A black augite altered to serpentine has been found at Fahlun.

The change requires the removal of $3\dot{Ca}$ from $\dot{Mg}^3\dddot{Si}^2+\dot{Ca}^3\dddot{Si}^2$ (augite), and the addition of $6\dot{Mg}, 6\dot{\mathbf{H}}$, thus affording $2\dot{Mg}^3\dddot{Si}^2+3\dot{Mg}\,\dot{\mathbf{H}}^2$ (serpentine).

Serpentine with the form of Hornblende.—Crystals of actinolite altered to serpentine have been observed near Presnitz, in Bohemia, and hornblende crystals at Easton, New Jersey. The graywacke of Plauen, Weischlitz, and Geilsdorf, affords other localities of these hornblende pseudomorphs.

From $4[\dot{Ca}\,\dddot{Si}+\dot{Mg}^3\dddot{Si}^2]$ remove $4\dot{Ca}$ and add $15\dot{Mg}, 18\dot{\mathbf{H}}$, and we have $3[2\dot{Mg}^3\dddot{Si}^2+3\dot{Mg}\,\dot{\mathbf{H}}^2]$, or 3 atoms of serpentine.

Serpentine with the form of Olivine.—Quenstedt has shown that crystals of serpentine from Modum in Norway, have the form of olivine, and in Poggendorf's Annalen for 1835, explained the chemical changes passed through in turning olivine into serpentine. Some of the crystals are four inches long; they usually have rounded angles and little lustre. The change he explains as follows:—

From 4 of olivine $(\dot{Mg}^{12}\dddot{Si}^4)$ remove $3\dot{Mg}$ and add $6\dot{\mathbf{H}}$, and we have $2\dot{Mg}^3\dddot{Si}^2+3\dot{Mg}\,\dot{\mathbf{H}}^2$, the formula of serpentine. The $\dot{Fe}$ (iron) in the olivine is supposed to be removed with the $3\dot{Mg}$.*

Water therefore is the only agent required in this change, though carbonic acid may be presumed to aid, as the gangue contains bitter spar. Tamnau has objected to this origin of these serpentine crystals on the ground of the extensive changes that must have been required in producing the wide-spread beds of

* If the iron in the olivine is to the magnesia as 1 to 3, the formula of olivine is then $(\dot{Mg}^{\frac{3}{4}}+\dot{Fe}^{\frac{1}{4}})^3\dddot{Si}$; 4 atoms of which contain $\dot{Mg}^9+\dot{Fe}^3+\dddot{Si}^4$; to this add the $6\dot{\mathbf{H}}$ and remove the $\dot{Fe}^3$, and we have without other change simply serpentine as above.—D.

serpentine; and also that crystals of olivine of the size of these crystals of serpentine had not been observed. Other reasons are brought forward by him for doubting Quenstedt's view, but they appear unsatisfactory. Breithaupt has long since suggested that serpentine may be an altered hornblende rock or Diorite; beds of Diorite in Saxon Voigtland sometimes have the characters of serpentine, and there is good reason for believing that all serpentine, as well as its contained minerals, is actually of metamorphic origin. The occurrence of so many pseudomorphs consisting of steatite, an allied mineral, favors this view. The exact imitation of olivine in these serpentine crystals, and their rounded forms and dull lustre, leave little doubt that they are actually altered crystals. Besides, instances of olivine altered to a greenish or brownish yellow steatitic mineral, have been described by Reuss as occurring in Bohemia and elsewhere.

Hornblende with the form of Augite.—The Uralite of Rose, a mineral with the form of hornblende and cleavage of augite, Dr. Blum shows to be an altered hornblende. He mentions various instances of the singular mixture or union of the two minerals, which he explains by supposing this change to have been partially carried out. He describes druses of crystals from Arendal, Norway, which have the form of hornblende, but nothing of its texture within, and which he concludes therefore to be pseudomorphs of hornblende. Other examples of this kind of pseudomorph are said to occur in porphyry near Miask, near Predazzo in the Tyrol, at Mysore in Hindostan, and elsewhere. Dr. Blum also mentions a greenish white augite from Orange County, N. Y. in the Leonhard collections, which he supposes to have undergone the same change from hornblende. This is indicated both by its structure and angles.

The metamorphosis in the composition producing this change is in general an increase of the bases. The varieties of the two minerals differ so much that it becomes difficult to represent the change by means of the formulas.

Chlorite with the form of Garnet.—This pseudomorph in dodecahedrons has been observed in Saxony associated with granular limestone; also near Frammont and near Berggieshübel.

From $\dot{C}a^3\,\dddot{S}i + \dddot{\mathbf{F}}e\,\dddot{S}i$ (garnet) remove $3\dot{C}a$, $\dddot{\mathbf{F}}e$, and add to the same $3(\dot{M}g, \dot{F}e)$, $\dddot{\mathbf{A}}l$, $2\dot{M}g\,\dot{\mathbf{H}}^2$, and the new substance (chlorite) is obtained $(\dot{M}g, \dot{F}e)^3\,\dddot{S}i + \dddot{\mathbf{A}}l\,\dddot{S}i + 2\dot{M}g\,\dot{\mathbf{H}}^2$.

Chlorite with the form of Hornblende.—At Greiner in the Tyrol there is a deposit of mica slate situated between gneiss and hornblende rock; and the hornblende is changed to a leek green and dark green chlorite, some of the folia of which are an inch or more broad. Rose describes similar facts, and mentions some crystals of hornblende that were chlorite externally to a line or more in depth. In the change $2(\dot{C}a\,\dddot{S}i+\dot{M}g^3\,\dddot{S}i^2)$ loses $2\dot{C}a$ and receives $9(\dot{M}g, \dot{F}e)\,3\dddot{\mathbf{A}}l$, $12\dot{\mathbf{H}}$, thus producing $3[(\dot{M}g^3, \dot{F}e^3)\,\dddot{S}i+\dddot{\mathbf{A}}l\,\dddot{S}i+2\dot{M}g\,\dot{\mathbf{H}}^2]$, or 3 atoms of chlorite.

Among the pseudomorphs of metallic minerals we cite only the following:—

Brown Iron Ore with the form of Pyrites.—The change of pyrites to brown iron ore appears to be a very common one in nature, and is in progress at the present time. It consists in the removal of the sulphur from the pyrites, (sulphuret of iron,) and the substitution of oxygen and water, and is supposed to take place generally by the formation first of a hydrated sulphate of iron, the sulphur and iron each uniting with oxygen, and then, following this, a removal of the sulphuric acid by some alkali or earth in the vicinity. Instances are given of gypsum thus produced by this acid combining with the lime of the gangue. A more direct mode, without the change to a sulphate, is as follows: the water present gives hydrogen to the sulphur to form sulphuretted hydrogen, and oxygen to oxydate the iron; and with the oxyd thus formed, other portions of water combine and produce the hydrate of iron or brown iron ore. In this process some sulphur is set free, and thus Dr. Blum accounts for the incrustations of sulphur often found with decomposing pyrites, or in cavities originally occupied by this mineral. To illustrate this:—2 atoms of pyrites $[Fe^2\,S^4]$ with 6 of water $[H^{12}\,O^6]$ afford 1 atom of $Fe^2\,O^3, H^6\,O^3$ ($=\dddot{F}e^2\,\dot{\mathbf{H}}^3$, *brown iron ore*), and 3 atoms of sulphuretted hydrogen $[H^6\,S^3]$, besides 1 atom of sulphur which is set free.

The change producing these pseudomorphs commences with the exterior, and it is quite common to find crystals with a thin incrustation of brown iron ore. Cubes, pentagonal dodecahedrons and compound crystals thus altered are of frequent occurrence.

Among pseudomorphs in which there is a total change in the constitution of the mineral or a complete replacement of the

same by another, there are two distinct modes of formation. The substitution takes place either during the removal of the original mineral, or, afterwards, by infiltration into its mould.

Of the latter mode, are probably, as our author suggests, the pseudomorphs of anhydrite, gypsum, and polyhalite, with the form of common salt. The cubes of salt imbedded in clay were removed by solution, and the place afterwards occupied by the infiltrating anhydrite, gypsum, or polyhalite.*

Of the former mode, are most of the pseudomorphs of quartz. Implanted crystals are thus altered when there are no moulds to be filled up.

Another kind still, proceeds from the incrustation of crystals by another mineral and their subsequent removal, leaving a thin hollow mould with the external and internal form of the original crystal.

The various siliceous pseudomorphs are the most numerous and most interesting of this class. We have already enumerated them on page 68. The change is often complete through the crystal, the whole being altered to quartz. In other instances the interior is vacant, or consists of the original mineral still unaltered. Crystals of fluor spar, consisting of quartz except a small fluor nucleus, are noticed by Blum. An instance is given by our author of altered calc spar in which the silica penetrated between the laminæ, forming a series of plates, and the remaining lime afterwards removed left a cellular crystal with the general structure of the calc spar. Their surfaces are generally rough or drusy, but sometimes are smooth, with the edges and angles sharp.

An instance is stated of a crystal of heavy spar, containing a concentric layer of brown iron ore about the distance of a line from the exterior surface, which was altered to quartz and still retains unchanged the layer of brown iron ore. The silica was infiltrated through this layer to the very centre of the crystal without disturbing it.

* The hopper-form clay crystals found in the red marl of the Onondaga salt region, appear to be casts of hopper-form crystals of salt. These hollow, pyramidal crystals were imbedded in the clay, (after being produced by the evaporation of salt water over the clay,) and subsequently being dissolved out, left clay casts of their singular forms.

Besides the siliceous pseudomorphs, others of special interest are those of feldspar with the form of calc spar, silicate of zinc with the form of calc spar and other minerals above enumerated, of tin ore with the form of feldspar, peroxyd of iron with the form of calc spar, brown iron ore with the form of heavy spar, fluor spar, calc spar, bitter spar, quartz, &c.

The account of the changes of calc spar to silicate of zinc are quite interesting. When complete, the crystals consist wholly of granular silicate of zinc, with the interior porous but never hollow. When less complete, zinc has incrusted and penetrated between the cleavage laminæ of the lime, some of the latter being yet included. The silicate of zinc which has here produced these pseudomorphous changes, appears to have in part proceeded from zinc blende in the vicinity. Dr. Blum supposes the first change to have been to sulphate of zinc, and then through the action of siliceous waters to a silicate, the sulphuric acid going at the time into combination with lime and forming gypsum, a mineral observed by Zimmermann at the locality.

The pseudomorphs of *Tin Ore with the form of Feldspar*, come from the mine of Huel Coates in Cornwall. They are mostly compound crystals with a rough exterior, and consisting of granular tin ore more or less mixed with granular quartz. Anker has described similar pseudomorphs which are tin ore in the middle and pure unaltered feldspar at each end. Blum makes mention of other specimens from St. Just and Huel Coates, which consist of granular quartz and white mica with disseminated tin ore. These specimens are found in the vicinity of the tin lodes of Cornwall, and appear to show as Dr. Blum states that the gangue of the ores was produced by the same process that formed these pseudomorphs. Von Dechen, in an account of the tin ore occurring in the syenite and feldspar porphyry of Altenberg, mentions that the rock adjoining the lode is altered to hornstone mixed with granular quartz, and contains disseminated tin ore; and also occasionally includes masses of quartz and mica with more or less tin. J. D. D.

ART. VIII.—*Observations on Pseudomorphism;* by J. D. DANA.

NOTWITHSTANDING the exact balancing of chemical formulas which we find through Dr. Blum's work, there is yet much mystery with regard to the origin and formation of Mineral Pseudomorphs. The elements removed and the amount added, may be laid down with mathematical exactness, but that the change has consisted in precisely such a removal and addition, is by no means sure. Moreover, in searching for the causes of pseudomorphous changes, it appears to have been too much the method to look for distinct causes for each separate instance of pseudomorphism: whereas we deem it probable that some few general principles will yet be ascertained, that will embrace and explain the whole subject.

Although we cannot hope to remove all the obscurity that rests about this subject, yet we may venture to offer some considerations in its elucidation, such as appear to result from the known causes acting in nature, and the facts that have passed in review. Could we believe with some late chemists, in the transmutation of the elements, we should consider this a fruitless subject of investigation, since in the midst of the many possibilities which such an hypothesis creates, we should hardly know which to choose. But the received principles of chemical science, are believed sufficient for these explanations, without the aid of such speculations.

Viewing pseudomorphs with reference to their origin, we may make the following distribution of them: those produced,

1. BY INFILTRATION; in which a cavity previously occupied by a crystal, is refilled by some other mineral. A cubic crystal of salt in clay, is removed by percolating water, and the cavity afterwards filled with gypsum. In this there is nothing chemical; it is simply a mechanical deposition into a ready formed mould.

2. BY INCRUSTATION; in which a mineral incrustation covers a crystal, which crystal is subsequently removed by some process of solution. Like pseudomorphs by *infiltration*, this process is mechanical—a simple deposition of foreign matter around a crystal. The process by which the original crystal was removed is a separate enquiry, and one of much interest.

3. By Replacement; in which one mineral gradually replaces another, assuming at the same time its form, without any interchange of elements; for example, the siliceous cubes, pseudomorphs of fluor spar, in which silica replaces the original fluor, and has taken on its cubic form. Here the process is in a certain sense chemical, and is wholly different from the simple act of deposition, by which the first two kinds of pseudomorphs above mentioned, were formed.

These three so different classes of pseudomorphs are included together by Dr. Blum, and constitute his second section, headed "Verdrängung-Pseudomorphosen," or pseudomorphs by expulsion.

4. By Alteration; in which some of the elements of the original mineral are removed, or exchanged, or others added. Thus anhydrite becomes gypsum by the addition of water; feldspar becomes kaolin by the addition of water, and removal of potash and some silica.

This class includes all the pseudomorphs in Dr. Blum's first section, his "Umwandlungs-Pseudomorphosen," or pseudomorphs by exchange. The change producing them is wholly chemical, being the result of chemical affinities.

Dr. Blum's subdivision of this class, although convenient for description, is objectionable when considered with reference to the formation of pseudomorphs. The change of hornblende to steatite, placed in his *first* subdivision, is undoubtedly due to the same cause that produced the change of augite, feldspar, mica, &c., to steatite, given in his *third* subdivision; and the first mentioned, should be placed, in a natural arrangement, near the latter. The following distribution is proposed: but much further investigation is required before it can be fully carried out.

a. Pseudomorphs that are formed at the ordinary temperature, and result from atmospheric agents.

b. Pseudomorphs that proceed from the same and other agents, but only under the action of heat.

5. By Allomorphism; in which a substance under one of its dimorphous forms, changes to the other without altering the external form.

The processes by which pseudomorphs of the first two kinds (*by Infiltration* and *by Incrustation*) have resulted, are too simple

to require farther remark. The character of these crystals will be gathered from our citations from the work of Dr. Blum. We shall allude, on a following page, to the causes that may have been instrumental in removing the crystals.

PSEUDOMORPHS BY REPLACEMENT.

The pseudomorphs *by replacement,* are considered the most singular of altered crystals. In some way, the substance of a crystal is entirely removed, and at the same time is replaced by some other material, without changing an angle or plane. Yet these altered crystals appear to be little more singular in their mode of formation than the common petrifaction of wood. The particles of wood as they pass off are immediately replaced by the petrifying material, and so neatly, as to leave every fibre still distinct after the change to stone. There is only this difference in the process,—gradual decomposition removes the wood; while in most of these pseudomorphs some solvent or chemical agent is required to carry off the original mineral: and this distinction is more apparent than real.

The nature of the solvent or chemical agent is the unexplained mystery with regard to these pseudomorphs.

It is a fact worthy of special consideration, that a large majority of these altered crystals are siliceous. The silica of which they are constituted we may safely conclude to have been in solution, and some siliceous fluid, therefore, must have been operating upon them during the change. Was this fluid hot or cold? Was it a simple solution of silica, or were other salts present? A solution of silica, whether resulting from the decomposition of feldspar at the ordinary temperature, or whether proceeding from submarine volcanic action, will in either case contain other substances. The alkali of the feldspar, potash or soda, passes off with the liberated silica; and in the latter case, the heated waters, if marine, will include both soda and magnesian salts. Such are some of the elements that may have been active in producing these changes. If we may suppose the solution to have been heated, still more efficiency is given to the chemical agents it may contain, through the dissolving power of hot water itself.

But do we need other decomposing chemical agents besides a heated solution of silica in water? Is not the process one of removal by simple solution, and a cotemporaneous substitution of

silica? A crystal of calc spar in a hot siliceous fluid, being exposed to solution from the action of the water alone, the silica, depositing itself gradually on a reduction of temperature, takes the place of the lime as soon as set free. This appears to be the process by which such changes have taken place. Every silicified fossil is an example of this pseudomorphous process; and instead of its being confined to the few silicified crystals, instances are distributed through a large part of the sedimentary formations of all ages.

There appears to be no union of the silica with the liberated lime, since, although silicified fossils are so common, we find nothing of the *silicate of lime*, which would thus result and show itself, either in the adjoining rocks or the fossil itself.

The process then, is probably a mere solution, and an attending substitution. There appears to be something in the chemical forces excited among the molecules, by the process of solution, when very slow and gradual, which leads the molecules of any body that may be passing at the time from a liquid state, to take the place successively of each molecule that is removed; and thus it is that the original form to the minutest stria, is so exactly assumed by the substituting mineral.

Moreover, as a liquid, saturated with one salt, will not take up as much of another, the solution of the lime in the case under consideration may be the occasion of the deposition of silica in its place.

Fluor spar and other minerals, may undergo this change in the same manner. Heavy spar is stated in our chemistries, to be entirely insoluble; yet there is no doubt that many of its crystallizations in nature have taken place from solution. Cavities in crystals of this mineral have contained a fluid which on evaporation, afforded crystals of barytes. We are not therefore authorized to assert the entire insolubility of heavy spar under all circumstances of *heat* and *pressure*. This mineral is found occupying cavities and filling veins in sedimentary limestones, that do not show the least trace of the effects of heat. We must suppose heated waters acting under pressure to have been the solvent in these cases, but not heated so highly as to crystallize the sedimentary limestones.

Simple solution without decomposition appears to be the most probable view of the change, as in the case of the silicified fossils. The same explanation embraces all the various siliceous

pseudomorphs, though so different in composition and character. We may suppose carbonic acid to be present, to aid in carrying off the calc spar in order to produce the siliceous pseudomorph; but this explanation would not extend to sulphate of barytes, fluor spar, &c. Besides, it appears improbable that the siliceous solutions that have altered so many calcareous fossils, should have contained carbonic acid.

The reason that silica is so common in pseudomorphs, as well as so common a material in the constitution of fossilized wood and shells, consists in its ready solution in water at high temperatures under pressure, whenever an alkali is present, as is seen in many volcanic regions; and its ready deposition again as the waters cool. Soluble minerals cannot of course form pseudomorphs of this kind; and lime, which is slightly soluble, is a rare material for this purpose, because it is not as readily deposited under the circumstances supposed. Yet we have calcareous petrifactions, which are formed from cold concentrated solutions of carbonate of lime, in carbonated waters; the lime being deposited as the waters evaporate, and the excess of carbonic acid passing off.

Admitting the preceding views, we comprehend also the formation of other common pseudomorphs in this division, consisting of *brown iron ore.* This mineral acts like silica in depositing itself in the place of the successively removed particles of the original mineral. The beds of this ore have proceeded evidently from more or less perfect solutions, as the stalactitic forms of the mineral prove. And should any process remove the material of a crystal exposed to such a solution, this iron ore might gradually take its place. It has not the power, like silica, of decomposing carbonate of lime under any circumstances, and consequently it is inefficient, except in making itself simply a substitute for the removed mineral.

The pseudomorphs of *peroxyd of iron* are often siliceous within, and it seems that the waters containing the iron, were also siliceous. The ironstone petrifactions of wood, so common in some formations, have often the hardness of quartz. These facts, in connection with this—that the iron is the anhydrous peroxyd instead of the hydrous brown iron ore—afford evidence that the petrifying waters were siliceous, and heated to a high temperature, the iron ore not being hydrous on account of the latter condition.

The change of *datholite* to *chalcedony*, (Haytorite,) we are inclined to place in the same category with the above, although considered by Dr. Blum, an instance of *alteration* rather than *replacement*.

PSEUDOMORPHS BY ALTERATION.

The pseudomorphs by alteration, although seemingly rendered more intelligible by means of the chemical formulas than those we have just considered, are yet in many cases more difficult of satisfactory explanation.

Before proceeding with our remarks upon them, we would direct attention to the small number of minerals constituting these pseudomorphs, as shown in the catalogue given on pp. 67, 68. Of earthy species, there are only the following; calc spar, gypsum, heavy spar, Dolomite, mica, kyanite, hornblende, kaolin, cimolite, Prehnite, the magnesian minerals, steatite, talc, serpentine, and chlorite, and rarely quartz with some of its varieties, and opal.

For the elucidation of these pseudomorphs, we have above distributed them into,

(1.) *Those formed at the ordinary temperature;* and

(2.) *Those requiring an elevated temperature.*

I. *Pseudomorphs formed at the ordinary temperature.*

Pseudomorphs of the first of these divisions, result from the agency of the elements of the atmosphere in connection with moisture; but the process is usually more or less dependent on foreign substances in solution in water, such as its common impurities, *salts of lime*, *carbonic acid*, &c., and in many instances the results of mineral decomposition in the vicinity, aid in producing the change. They may be farther subdivided as follows; 1. Those resulting simply from atmospheric agents and moisture; 2. Those produced by the agency of gases, salts or acids contained in the water or atmosphere.

The following are a few examples in illustration of the first of these subdivisions.

Anhydrite to Gypsum.—A simple addition of atmospheric moisture.

Specular Iron to Brown Iron Ore.—The same.

Red Copper Ore to Malachite.—Combination with the carbonic acid of the atmosphere and moisture.

Galena to Sulphate of Lead.—A simple oxydation of the sulphur and lead.

Pyrites to Brown Iron Ore.—By the decomposition of water the sulphur forms sulphuretted hydrogen, and the iron is oxydized; water then combines with the oxyd formed, (see page 78.)

Pyrites to Red Oxyd of Iron.—Probably the same as the last, except that the oxyd formed does not combine with water.

Carbonate of Iron to Brown Iron Ore.—From contact with moisture, the surface of the carbonate of iron is dissolved; and then on subsequent evaporation, the carbonic acid passes off, the iron becomes peroxydized, and by uniting with other portions of water, forms the resulting brown iron ore. This process repeated for a period of time, changes the crystals throughout.

The evaporation of chalybeate waters containing carbonate of iron in solution, illustrates this process; carbonic acid escapes as above described, and the iron falls as a hydrated peroxyd or brown iron ore. It is a common laboratory experiment.

Galena to Minium.—Similar to the change of pyrites to brown iron ore, except that the resulting oxyd does not combine with water. A *hydrated* oxyd of lead has not been observed in nature.

Galena to Carbonate of Lead.—Similar to the last, except that the oxyd of lead combines with carbonic acid.

Carbonate of Lead to Pyromorphite.—Phosphates so frequently result during animal decomposition, that we deem it quite probable that this pseudomorph might have received its phosphoric acid from this source.

Feldspar to Kaolin.—This change is attributed to the disposition of the potash to combine with water and carbonic acid. By this means the equilibrium of the compound is disturbed. New attractions then begin to work among the remaining elements, and kaolin is the result—at the same time, those elements capable of solution passing off which do not enter into the combination.

This example affords the general theory for many pseudomorphs of the more complex mineral species;—*Some one element or more, by the influence of external agents, enters into new combinations and is removed; this disorganizes the original compound and leaves the remaining elements free to combine anew; such as are capable, consequently unite by their affinities either alone or with water, (or other chemical agents present;) the excess, if any, and soluble, passes off in solution.*

It is not impossible that the change of feldspar takes place without the agency of carbonic acid, by means of moisture alone. (See page 70.) If so, we would suggest whether the moving cause in the change rests not in the tendency of silica, potash and water to combine, instead of the attraction between potash and carbonic acid? The silicate of potash may thus be removed; this silicate would however be soon decomposed by the carbonic acid of the atmosphere.

We cannot affirm but that some alumina also passes off with the hydrous silicate of potash, and that a *zeolite* as well as free silica is liberated, for the result might still be the same, proceeding as it does from the chemical affinities between the remaining elements and water. The possibility of such an effect shows how very unsatisfactory, as an explanation, is the mere statement that if $3\dddot{K}$, $8\dddot{S}$ be removed from 3 atoms of feldspar, and $6\dot{\bar{H}}$ be added, kaolin will result; (see page 70.) This is true; but we have no evidence that such is the "removal" and "addition." It is equally true that kaolin will proceed from 4 atoms of feldspar, if $\dddot{\mathbf{A}}l$, $\acute{K}a^{4}$, $\dddot{S}i^{12}$, be removed and $6\dot{\bar{H}}$ be added.

Without dwelling longer on this branch of the subject, we proceed to the next subdivision, mentioning a few examples only.

Carbonate of Barytes to Sulphate of Barytes.—The change of carbonates to sulphates, when within reach of a decomposing metallic sulphuret, or by the action of waters containing sulphuretted hydrogen in solution, is well understood.

Sulphate of Lead to Carbonate of Lead.—Among the salts of lead, the carbonate is the least soluble, and consequently, as chemistry has shown, any of the insoluble salts of lead may be decomposed by soluble carbonates. Carbonate of soda effects the change readily in sulphate of lead, when the two are heated together. Is it not possible that carbonate of lime, in the slow processes of nature, may occasion the same change, although not aided by heat?

Tungstate of Lime to Tungstate of Iron, (*Wolfram.*)—Probably due, by a double exchange, to the slow action of nascent sulphate of iron, proceeding from the decomposition of pyrites in the same rock; but whether heat be required or not, as in the process of the laboratory, we cannot say.

II. *Pseudomorphous changes requiring an elevated temperature.*

Magnesian Pseudomorphs.—The magnesian pseudomorphs appear to fall within this division. The magnesian minerals constituting them are talc, including the variety steatite, saponite or hydrous steatite, serpentine and chlorite. In the change of feldspar to talc, magnesia by its affinity for silica, expels alumina, and at the same time, the other elements of feldspar that cannot enter into the new magnesian compound, pass off.* The same takes place in the change of mica, kyanite, augite, &c. to talc. The general theory of the process, corresponds then with that stated on page 87, at bottom.

Magnesia either in solution or in the state of vapor, has acted upon the mineral and rocks that have undergone this change.

The idea of *magnesia in vapor* is an assumption as yet unauthorized by chemical science, except as a theoretical possibility. It may be *convenient* to summon the hypothesis to our aid, for the sake of an explanation; but as far as facts have been ascertained they stand against such a view. Many of the rocks so altered to magnesian, *contain water;* evincing thus that they have not been subjected to that immeasurable degree of heat, which the fancy might call up, for producing evaporation of this most fixed and infusible of the earths.

Magnesia compounds in solution are well known. Sea water is such a solution, and one that has existed, as geological facts testify, since geological changes commenced on the globe. And are not these pseudomorphs some of the effects resulting through its agency when under the influence of volcanic heat? The view we would here sustain, is the same already presented in a preceding volume of this Journal, namely, that the ocean waters superincumbent, and penetrating the rocks, heated by igneous action from below, have been the medium through which these changes have been effected; aided by additional magnesia and other elements which the heat and pressure would enable them to dissolve from the neighboring rocks.

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* Dr. Blum, speaking of this change, says that $6\dot{M}g$ (6 of magnesia) is substituted for $\dot{K}$, $\dot{A}l$, (1 of potash and alumina.) But is it not possible, considering the affinities engaged, that under the causes in action, the potash and its silica together entered into combination with water, and were removed thus in solution, and then the magnesia present displaced the alumina in the silicate of alumina that remained? See the remarks on the formation of kaolin, page 88.

We cannot doubt, especially when we consider the vast pressure of an ocean, that these waters, besides overlying, fill up all open spaces or caverns between the layers of submerged rocks, and probably the whole substratum of the ocean, when not too compact, is throughout permeated by them. Submarine eruptions opening to the fires below and sometimes ejecting lavas, would distribute heat around and thus give the waters increased power in their action upon rocks. This cause therefore is sufficient in its energy, and sufficiently extended in its influence. It must have been in action ever since the earth had an ocean and internal fires; for it is a necessary effect of all submarine volcanic action. Wherever a trap dyke is to be found on the globe in a vein of porphyry, there have been heated waters, permeating and superincumbent, and under the pressure of an ocean intensely heated.

Additional magnesia would be furnished these waters by the various augitic rocks, among which the traps are included; also by dolomites.*

The action of heated waters is often indicated in the regions of these pseudomorphs, by the rounded angles or pitted surfaces of otherwise unaltered crystals.

Other evidence that heated water has been the agent, is found in the frequent change of quartz to steatite. Hot magnesian waters alone, could have effected the slow solution of the silica and the introduction of magnesia, that constitute the change here indicated. Hot vapors it is true would equally dissolve silica, but they would not afford the necessary magnesia; and moreover, exposure to such vapors would have destroyed the form of the crystal.

This view is farther corroborated by the occurrence of *siliceous* pseudomorphs along with those of steatite. The steatitic spinels, also, of the same localities afford other proof, as the change in these crystals has consisted in a substitution of silica for alumina, thus making a *silicate of magnesia* out of what was before an *aluminate of magnesia*—a change that requires water and heat for the solution of the silica, and heat no less for effecting the transfer of elements.

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* The interesting analyses of B. Silliman, Jr. have shown that the ocean's waters through animal agency, (the growth of corals,) have afforded a great part of the magnesia that is contained in dolomites; (see this Journal, Vol. XLVII, p. 135.)

The fact that the majority of these pseudomorphs contain water, is other proof that the heat producing the change was not a dry heat, but was diffused through water. Dr. Blum does not seem to recognize the fact of the hydrous character of the steatitic pseudomorphs, in his work; yet analyses have shown that in very many instances the steatite is a hydrous mineral, and not true steatite. Serpentine and chlorite also contain a large per centage of water.*

Calc Spar to Bitter Spar.—This change comes under the same head with those just explained. A change of this kind does not require a complete solution of the lime; for late investigations have shown that molecular attractions take place at high temperatures, without solution of all the elements concerned in the change.

Carbonate of Lead to Minium.—Minium is easily produced from carbonate of lead, by means of heat.

Andalusite, Wernerite and Tourmaline to Mica.—These changes must have required the high temperature that crystallized the mica in the metamorphic rocks.

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* The agency of hot waters and vapors in producing changes in rocks, though recognized by many geologists, does not seem to have received sufficient attention. When we consider the number of hot springs on the surface of the earth in regions of modern volcanic action, and in others not of this nature, when we remember the many eruptions of hot water, even from subaerial volcanoes, and when farther we have before our eyes the wide-spread effect of volcanic action beneath the sea, can we refuse to the agency of heat, thus conveyed by vapors and flowing waters, a *large part* at least of the various metamorphic changes manifest on the surface of the earth, especially if we take into view, the condition of a vast volcanic region in full submarine action, its floods of melted rocks, its opened fissures, for a long period in action, its fountains of boiling waters and rising vapors? The whole surface of the earth evinces that this submarine action, under an ocean's pressure, has been almost coextensive with it. The vast number of dykes that traverse the rocks, suggest the same fact. Where are the effects of this heat if not in these pseudomorphic and metamorphic changes? Prof. Keilhau attempts to account for the crystallization of the dolomites, by the hypothesis of slow molecular changes taking place at the ordinary temperature. But why refuse the aid here proffered? The fact that one part of a sedimentary limestone is crystallized while another is not, is fully explained by this view; while his theory serves only to increase the mystery that hangs around this subject. The fact also that these crystallizations have taken place without evidence of the intense heat necessary for fusion is fully explained; for, as Keilhau states, crystallization has been lately shown by many facts to take place without fusion or even softening, yet not, as this author would urge, without some increase of temperature.

Augite to Opal.—Dr. Blum suggests that this change is probably effected by means of the sulphur vapors of the volcano decomposing the volcanic rock. The writer has seen siliceous incrustations produced in this way at the sulphur beds of Kilauea, Sandwich Islands, where the basaltic lavas are gradually crumbling down, through this action, to a yellow earth. The sulphuric acid removing the lime of the augite, forms sulphate of lime, which is found in snowy fibrous seams and incrustations.

We do not attempt to offer explanations of all the several instances of pseudomorphs. A more particular examination of the various localities, the associate minerals and their situations in the rocks, is necessary before this can be done.

The principal obstacle in the way of chemically investigating and imitating these processes in nature, lies in these two facts; 1, that it is difficult by laboratory experiments, to appreciate the effect of agents acting slowly for a long period of time, under circumstances of temperature and electric forces beyond our cognizance; 2, we cannot know fully the exact condition and composition of waters intensely heated, under pressure, and rendered by this means capable of dissolving many refractory minerals.

In the preceding remarks, it has been our object simply to discuss the principal agencies that must have been in operation, in order to prepare the way for a more complete elucidation of the subject, by future developments.

The importance of these discussions to geology, is not to be measured by the length of the catalogue of pseudomorphs. The same process that has altered a few crystals to quartz, has distributed silex to fossils without number, scattered through rocks of all ages. The same causes that have originated the steatitic scapolites, occasionally picked out of the rocks, have given magnesia to whole rock formations, and altered throughout their physical and chemical characters. If it be true that the crystals of serpentine are pseudomorphous crystals, altered from chrysolite, it is true also, as Breithaupt has suggested, that the beds of serpentine containing them, are likewise altered, although often covering square leagues in extent, and common in most primary regions. The beds of steatite, the still more extensive talcose formations, contain every where evidence of the same agents. The deposits of the so-called Rensselaerite, in northern New York, are other examples of the widely extended influence of the pseudomorphic agencies.

ART. IX.—*Scraps in Natural History*, (*Molluscs;*) by Dr. JOHN T. PLUMMER.

THE limited area to which I have confined my conchological observations, and the want of suitable opportunities for prosecuting my inquiries into the habits of such molluscs as are found within it, have kept my physiological notes on this subject very meagre. I will insert them here, however, for the purpose of preserving the integrity of my plan of accompanying the catalogues prepared for this Journal with some remarks upon the habits and physiology of the respective classes of animals enumerated; and because, if they are not altogether novel, they may prompt others to more extended research into the modes of living of the molluscan race.

Snails.—I confined several species together in a box filled with vegetable mould; and in a few hours afterward I found some of them had descended several inches into it, while others were just opening a passage for the admission of their shells, which they also soon dragged beneath the surface entirely out of view. One, a *Helix solitaria*, had its lip broken off, and made no attempt to burrow, but commenced repairing its loss of shell shortly after it was deposited in the box. The process appeared to consist in bringing a border of the mantle armed with a row of papillary glands into contact with the fractured edge; and not precisely upon it, but just within it, depositing the calcareous matter. The reparation proceeded with so much rapidity, that in forty hours four tenths of an inch of shell was added, and then the operation apparently ceased. Another Helix, of a different species, added one eighth of an inch every two days for nearly a week. Some time after their confinement to the box, several articles were laid upon the mould for their use; in a few days a large portion of a rotted chip was consumed, a considerable quantity of radish was eaten, and a common house-fly, with the exception of the wings, was totally devoured. A patch was eaten out of some crimson colored paper, and the filamentous egesta afterward being beautifully stained with the same color, marked the duration of the digestive process; and evinced that the tingent material underwent no perceptible change in the alimentary passage.

Physæ.—Capturing some of the *Physa heterostropha* while floating on the surface of a brook, I placed them in a bowl of water, and entertained myself with their nautical skill, as they directed their devious course over the fluid. The mouth of the shell is turned upward, and by visible undulations of the molluscan portion, which scarcely protrudes beyond the lip of the shell, an easy, gliding motion is communicated to the calcareous vessel.

Shells about Richmond, Wayne County, Indiana.

To know the barrenness of a locality in reference to *geographical distribution* is as desirable to the naturalist as the knowledge of the fruitfulness of another district. And to trace to their proper inviting and repelling causes the presence or absence of objects of natural history in any given territory, is an interesting item in his labors. To this end local catalogues, accompanied with appropriate sketches of the district in question, may be accumulated with advantage in the literary repositories of science. And more especially has it appeared to me to be desirable that lists of the reptiles, insects, fishes, plants, &c. of newly settled sections of the country should be made out, not only for present purposes, but for the future student of nature who may traverse the same regions when highly populated and improved, and the influence of terrestrial cultivation on wild organic nature be determined. Impressed with this view, I have for years past directed my attention to the animal and vegetable kingdoms around me, and have been endeavoring to perfect catalogues of their several subjects. A list of our mammals, and a sketch of our geography and geology, have already been published in this Journal. I now transmit the names of such molluscs, terrestrial and fluviatile, as I have been able to find. The catalogue it will be perceived is not copious; the total absence of Unios is perhaps attributable to the want of larger streams than our district furnishes; and the absence of some others may be owing to the newness of the country, and to the examination being confined to a single observer. The nearest approximation of the genus Unio that I have been advised of, is about twenty miles south of Richmond, whence I obtained a fine *U. Cardium.*

Helices.

1. Helix albilabris, Say, frequent.
2. H. arborea, Say, common.
3. H. alternata, Say, common.
4. H. clausa, Say, rare.
5. H. elevata, Say, common.
6. H. fallax, Say, common.
7. H. fraterna, Say, rather rare.
8. H. fuliginosa, Griffith, frequent.
9. H. hirsuta, Say, common.
10. H. inflecta, Say, common.
11. H. ligera, Say, infrequent.
12. H. multilineata, Say, frequent.
13. H. palliata, Say, frequent.
14. H. perspectiva, Say, common.
15. H. profunda, Say, frequent.
16. H. solitaria, Say, frequent.
17. H. tridentata, Say, frequent.
18. H. thyroida, Say, common.
19. H. zaleta, Say, common.

Limaces.

1. Limax —— ?

Planorbes.

1. Planorbis bicarinatus, Say, common.
2. P. parvus, Say, frequent.
3. P. trivolvis, Say, common.

Helix alternata. Great numbers appeared in a garden under some vegetable rubbish during rainy weather.

Helix multilineata. All that I have found here are darker colored than those from some other localities; perhaps owing to the ferruginous character of the swamp which they inhabit.

H. tridentata. All I have yet met with more closely resemble the variety from the northeastern states than those from the west, as exhibited by Binney in the Boston Journal of Natural History.

H. thyroida. Many hundred empty shells were found in a hollow stump, apparently brought there and stored up (when filled with the snail) by some little animal. Many of the shells were indented as if by the teeth of the captor.

Planorbes. The habitat of these appears to be comparatively still waters, as ponds and mill races. Some of mine are quite one inch in diameter.

Paludinæ.

1. Paludina limosa, Say, rare.
2. P. lapidaria, Say, rare.

Physæ.

1. Physa heterostropha, Say, common.
2. P. gyrina, Say, common.

Lymneæ.

1. Lymnea elodes, Say, frequent.

Melaniæ.

1. Melania exilis, Haldeman, common.

Succineæ.

1. Succinea obliqua, (campestris,) Say.

Anodontæ.

1. Anodonta Ferussaciana, Lea, frequent.

Cyclades.

1. Cyclas similis, Say, common.

Alasmodontæ.

1. Alasmodonta edentula, Say, frequent.
2. A. calceola, Lea, frequent.

Richmond, Wayne County, Indiana, April, 1844.

Physæ. I have found these only in running water.

Melaniæ. Thousands are destroyed by swine in low stages of our streams. These quadrupeds turn over the flat stones, to the under side of which the *M. exilis* adheres, and greedily devour the molluscs.

Succinea obliqua. I found great numbers of these adhering to the trunk of a tree six and eight feet high from the *swamp* in which the tree stood.

ART. X.—(1.) *Action of Solutions of the Neutral Phosphates of the Alkalies upon the Carbonate of Lime, and some other insoluble Carbonates;* (2.) *Source of Fluorine in Fossil Bones;* (3.) *Composition of the Marl from Ashley River, S. C., with an extract from a letter written by Prof. Bailey of West Point;* (4.) *Existence of the Oxide of Cobalt in South Carolina;* by J. LAWRENCE SMITH, M. D.

I. *Action of Solutions of the Neutral Phosphates of the Alkalies upon the Carbonate of Lime, &c.*

IT is a fact, that notwithstanding the advanced state of the science of chemistry, we are ignorant of some of the laws that govern the relative affinities of acids for bases, and the action of neutral salts upon each other. It is true, such and such acids are ranked according to what is termed their strength, and such bases are said to be more powerful than others; still from time to time facts are developing themselves that contradict these established rules. The decomposition of the sulphate of lead by certain neutral alkaline salts, (Am. Journ. XLVII, 81,) I thought could be explained upon a known law, that when there existed two acids and two bases in solution, (the sulphate of lead being dissolved by the salts used,) the stronger acid sought the stronger base, and the feebler acid had to combine with the feebler base, notwithstanding being originally in combination with an alkali. But how are we to explain the fact about to be mentioned, which so far as my information goes, has not been previously observed; it is that the feeblest solution of the *neutral phosphate of soda or potash* will decompose the *carbonate of lime* in the cold, giving rise to carbonate of soda and phosphate of lime.

This fact was first observed while analyzing the ashes of a plant, which was fused with carbonate of soda, for the purpose of estimating the phosphoric acid. The fused mass was thrown into about four ounces of water, and digested at about 180° Fahr. for a couple of hours; the insoluble portion was separated, and treated with an acid, when to my astonishment it dissolved with but a *very slight* effervescence, in fact with the escape of only a bubble or two of gas, the carbonate of lime expected not being present. It was known that this circumstance could not arise from a want of decomposition of the original matter, as it was kept fused

for half an hour with four times its weight of carbonate of soda; therefore the only rational conclusion was, that the phosphate of lime was in the first case decomposed by the soda, but was subsequently reformed upon treating the fused mass with water. This has been verified by direct experiment.

Twelve grains of neutral phosphate of soda, and six of carbonate of lime, were digested for two hours in four ounces of water at 180° Fahr., when the carbonate of lime was found almost completely decomposed, and the clear solution upon evaporation furnished carbonate of soda.

Six grains of precipitated carbonate of lime, added to a solution of twenty grains of phosphate of soda, (equivalent proportions of each,) in one ounce of water, were kept in a vial for one month, the temperature never exceeding 65° Fah. At the expiration of this time the insoluble portion contained three and a half grains of phosphate of lime, corresponding to a decomposition of about two and a half grains of the carbonate of lime; the soluble portion indicated a corresponding portion of carbonate of soda.

Other insoluble carbonates were experimented with, as the carbonates of magnesia, strontia, baryta and lead; the results were the same, differing only in degree. Even hydrated alumina decomposes slightly the phosphate of soda, when boiled with it for a length of time.

I tried two other neutral salts, the acids of which produce insoluble salts with lime, to see if they would act in the same way. The chromate and the tartrate of potash were digested a length of time upon the carbonate of lime, but no decomposition ensued.

I shall not attempt to seek for an explanation of this at present, but shall go on collecting facts of a similar character, to endeavor to find out some general principle that may operate in this and in other cases. This fact itself would not be published at the present time, if it were not of the greatest importance, to put analytical chemists upon their guard; for but a few days ago an individual wrote me that he was estimating the phosphate of lime in a certain class of bodies by fusing them with carbonate of soda, which will certainly be productive of some error; and although it is to be regretted that our methods of arriving at phosphoric acid in analysis may be diminished by this fact, still it will only stimulate us to find out some other to solve this, one of the most difficult and annoying problems in analytical chemistry.

Charleston, S. C., Oct. 29, 1844.

II. *Source of Fluorine in Fossil Bones.**

The analyses of fossil bones communicated by MM. Girardin and Preisser to the Academie des Sciences, Oct. 1842, afford the only well detailed numerical results of the composition of this class of bones that we possess. The authors appear to have bestowed considerable care upon their research, and their estimate of the proportion of fluoride of calcium present was as follows:

	Per cent.
A metacarpal bone of a Bear from the cavern of Mialet,	1·09
Tusk of an Elephant, ...	2·64
Vertebra of a Plesiosaurus, ...	2·11
The great bone of the Pœkilopleuron Bucklandii, .	1·50
Rib of an Ichthyosaurus, ...	1·02
Head of the same Ichthyosaurus, ...	1·65
Bone of the Lamenton from the tertiary formation in the environs of Valognes, ...	9·12

This fluoride would appear to form a distinguishing mark between fossil and recent bones, although Berzelius has found it to exist in these latter, and Marchand in some recent experiments mentions the same fact; still many other chemists have not succeeded in detecting it. MM. Girardin and Preisser suppose that it was owing to some accidental circumstances that Berzelius was enabled to discover it in the cases that he examined, they having in no instance found it, although carefully sought for. My experience tends to confirm Berzelius in his statement, having in several cases obtained most decided evidence of its presence in recent bones, but in very minute quantity. In many instances I failed to detect it, and attribute the failure more to the minuteness of the quantity than to the total absence of it.

I would here remark, that in examining for fluorine in the ordinary way, by testing the effects of the hydrofluoric acid (liberated by the action of sulphuric acid) upon waxed glass with characters traced out, the process requires some precaution when the quantity present is supposed to be very small, for I have been able in several instances to obtain a permanent delineation of the characters traced, without the presence of fluorine. In these cases it is caused by the action of the vapors of either sulphuric or hydro-

* This and the two following articles are extracts from communications made to the Association of American Geologists and Naturalists, at Washington, May, 1844.

chloric acid upon certain kinds of glass that contain a large quantity of metallic oxides, or upon glass the surface of which has been altered by the action of the air; there is however no apparent corrosion in these cases.

The existence of fluorine in fossil bones, and its doubtful, or as some say absolute, non-existence in those of recent animals, have induced MM. Girardin and Preisser to conclude that it did not belong originally to the bones of fossil animals, but has found its way there by infiltration after their death, and they appear to have come to this conclusion without having examined the chemical character of the formations from which the various bones were taken.

I have had an opportunity of throwing some light upon this subject, from the examination of two bones taken from the same calcareous deposit and within two feet of each other, the one cellular and the other compact. The cells of one of these bones were filled with small concretions of calcareous matter, evidently arising from the infiltration of some of the material forming the bed in which they lay; these concretions it would seem ought certainly to contain a portion of whatsoever matter had been infiltrated, as all infiltrations must have passed in together. These concretions, carefully detached from the bone, were examined especially for fluorine, but not the slightest trace was found, while on the contrary a very small quantity of the compact part of the same bone, gave decided indications of the presence of this substance. This fact must certainly lead to the conclusion that the fluoride of calcium in the body of the bone was not infiltrated, for had it been otherwise, it would have been associated with matter known to be infiltrated, as the calcareous nodules.

The same cellular bone was examined as a whole, that is to say, without detaching the calcareous matter, in comparison with the compact bone from the same locality; and in the former there was found less fluoride of calcium than in the latter, contrary to what would have been the case had this fluoride been infiltrated.

Compact bone, . .	2·45	per cent. fluoride of calcium.
Cellular bone, . .	2·00	" " "

The deposit from which these bones were taken was analyzed, and fluoride of calcium detected, but in very small quantity; and whether it arises from disintegrated osseous matter, or belonged originally to the calcareous remains forming this bed, is of no

consequence; sufficient is it for us to know, that it has an organic origin, having been a part of either mollusca or vertebrated animals, and were it necessary to suppose that it could have existed in only one of these, I should unhesitatingly attribute its origin to the vertebrated animals, particularly on account of their abundant provision of phosphates. Bones were also examined that contained fluorine, when the deposit from which they were taken showed no traces of this element.

Dr. Daubeny has lately examined the question of the existence of fluorine in recent bones, and decided it in the affirmative.

It is not surprising that we should find the phosphates and fluorides associated in the animal kingdom, for in the mineral kingdom fluorine is a very common attendant upon the phosphates, as for instance in the Apatites, Wagnerite, Wavellite, Urinite, &c., and I think if we search the mineral kingdom we shall not find so constant an association of any two elements as fluorine and phosphorus. All the phosphates of the alkalies and earths contain fluorine.

If then this element is associated with the phosphates, they must exist together in the soils arising from the disintegration of the rocks containing these minerals, and the plants growing upon these soils would upon taking up the phosphates naturally appropriate the accompanying fluorides, which two classes of salts would subsequently pass to the same portion of the animal feeding upon these plants, namely, to the bones.

The reason why the existence of fluorine in recent bones is doubtful, may be owing to the fact, that the great mass of the phosphate of lime originally in the soil has from various causes disappeared, and with it the fluoride of calcium; and that the portion of this latter still remaining is so small, that notwithstanding the double condensation that it undergoes through the agency of plants and animals, it is not in sufficient quantity to come readily within the reach of our tests.

III. *Composition of the Marl from Ashley River, S. C.*

The epoch to which this formation of marl is referable, is not yet fully decided, but it probably consists of beds of different ages, the newest being as old as the eocene of Virginia and Maryland. It has been explored to the depth of 309 feet in boring a well. Specimens from depths varying from 110 to 309 feet,

have been sent to Prof. Bailey of West Point, who has already subjected them to microscopic examination, and a short account of his results will be found in the accompanying note.* A fuller detail may be expected from him at some future time, and when it does come it will no doubt be a rich feast for the naturalist of this country, prepared as it will be by a skillful hand.

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* *Extract of a letter from Prof. Bailey to J. L. Smith.*—" Charleston is built upon a bed of animalcules several hundred feet in thickness, every *cubic inch* of which is filled with myriads of perfectly preserved microscopic shells. These shells however *do not*, like those beneath Richmond and Petersburg, &c., belong to the siliceous infusoria, but are all derived from those minute calcareous-shelled creatures, called by Ehrenberg Polythalamia, and by D'Orbigny the Foraminifera. You are aware that Ehrenberg proved chalk to be chiefly made up of such shells, and you will doubtless be pleased to learn that the tertiary beds beneath your city are filled with more numerous and more perfect specimens of these beautiful forms than I have ever seen in chalk or marl from any other locality."

"The following are some of the results I have obtained:—

"1. The marls from the depth of 110 feet to 193 feet are certainly *tertiary* deposits, for I found them to contain Polythalamia of the family Plicatilia of Ehrenberg, (Agathestegens of D'Orbigny,) which family as far as is yet known occurs in *no formation older than the tertiary.*

"2. The beds from the depth of 193 feet to 309 feet contain so many species in common with the beds above them, that although I have not yet detected the Plicatilia, I yet believe they must also belong to the tertiary formation.

"3. The forms found in these beds agree much better with those detected by me in the eocene marls from Panumkey River, Virginia, than they do with miocene Polythalamia from Petersburg, Va., and I am consequently inclined to believe that they belong to the *eocene* epoch.

"4. All the marls to the depth of 236 feet present the Polythalamia in *vast* abundance, and in a state of surprising preservation. The most delicate markings of the shells are perfectly preserved, and some of the forms are so large that they may be easily seen with a common pocket-lens.

"5. The lithological characters of the marls from 236 feet to 309 feet differ from those above, and although the Polythalamia are still abundant, and many of the species appear to be the same as in the strata above, yet they are less easy to observe on account of the greater compactness of the marls, and the adherence of crystalline calcareous particles to the shells.

"6. The marls which you sent from the Cooper River, 35 to 38 miles above Charleston, also abound in Polythalamia, and so many of the species are identical with those found beneath Charleston, that they most probably belong to the same formation. This place on the Cooper River may be the outcrop of the very slightly inclined beds which exist under Charleston. [In this conclusion Prof. Bailey is correct.—J. L. S.]

"7. The Polythalamia to whose labors South Carolina owes so large a portion of her territory, are still at work in countless thousands upon her coasts, filling up harbors, forming shoals, and depositing their shells to record the present state of the sea-shore, as their predecessors, now entombed beneath Charleston, have done with regard to ancient oceans. The mud from Charleston harbor is filled not only with beautiful Polythalamian shells, but is also very rich in siliceous infusoria."

Organic remains are quite abundant in this marl, although in an imperfect state. Its composition is somewhat peculiar, and a knowledge of it may be of some general importance; it varies in the proportion of its ingredients, but seems to be constant as regards their character. From among several analyses the following is selected as being an average one.

Carbonate of lime,	65·8
Carbonate of magnesia,	2·4
Silica,	15·6
Alumina,	10·0
Phosphate of lime, with a small quantity of phosphate of magnesia,	5·0
Phosphate of iron, Fluoride of calcium, Crenate of iron, Crenate of lime, Ammonia, Organic matter,	1·2

The proportion of phosphate of lime is large, and may be owing to the impalpable remains of animals that must have frequented these early seas in myriads, or it may be peculiar to the little shelly remains of Polythalamia that form such a large portion of this bed. The fluoride of calcium, which I believe is here pointed out for the first time as existing in marls, does not owe its origin to any spiculæ of bony matter present in the specimen examined, at least none that the microscope could detect, so we must attribute it either to osseous matter triturated to an impalpable powder, or what is more probable, suppose that it forms a part of the calcareous covering of those animalculæ just alluded to, the remains of which form the foundation of the city of Charleston. The ammonia is held mechanically in the pores, associated perhaps with carbonic acid, and is easily rendered apparent by dropping caustic potash on the marl; this has been found present in all the marls I have examined, and the fluoride of calcium in several.

IV. *Oxide of Cobalt from Silver Bluff, South Carolina.*

The existence of this oxide was first brought to my notice by Prof. Ellet; it is accompanied by the oxide of manganese, and with it stains a coarse gravel found in the primitive region of

this state; these stains are in the form of streaks, varying in length and breadth; the sand has the appearance of coarse gunpowder and arises from the disintegration of mica granite. Hydrochloric acid readily dissolves this black matter with an evolution of chlorine; the solution is of a pinkish color, and affords a green salt when evaporated to dryness, from which it is evident that it must contain both the oxides of manganese and cobalt. It is perfectly free from iron, arsenic, and nickel, but at the same time it is impossible to obtain a solution of it free from iron, owing to the presence of ferruginous matter in the sand from which it is derived. This black matter has evidently originated from the disintegration of cobaltiferous oxide of manganese, minute particles of which are still to be traced, mixed with the sand. The relative proportions of the oxides are not always the same. One analysis gave—

Oxide of cobalt, ...	24·00
Oxide of manganese, ...	76·00
	100·00

The method by which these oxides were separated, is that recommended by Prof. Liebig, and one that deserves the notice of all analytical chemists engaged in the separation of the oxide of cobalt from other oxides; I allude to the method with the cyanide of potassium. The locality where this is found is one of the two or three in this country where cobalt is found under any form whatsoever, and the only one where it exists in the form of an oxide free from arsenic.*

* The *black earthy cobalt* from Missouri (mine La Motte) had of course not been seen by Dr. Smith when the above was written. We have analyzed it, and found it to consist of the oxides of cobalt, manganese, iron, copper; and traces of silica, lead, magnesia, &c., with about 17 per cent. of water. It generally contains about 40 per cent. of oxide of cobalt. A full notice of this interesting mineral will soon be published.—Eds.

ART. XI.—*Notice of the Medals of Creation, or First Lessons in Geology, and in the Study of Organic Remains;* by GIDEON ALGERNON MANTELL, LL. D., F. R. S., Author of the Wonders of Geology, &c. In two volumes, 12mo: Vol. I, containing Vegetables, Infusoria, Zoophytes, Echinodermes, and Mollusca; Vol. II, containing Fossil Cephalopodæ, Insects, Fishes, Reptiles, Birds, and Mammalia, with notes of Geological Excursions.

"Behold a new kind of medals, much more important and incomparably more ancient than all those of the Greeks and Romans."—KNORR, *Monumens des Catastrophes.*

"It is not one of the least advantages of these pursuits that they are altogether independent of external circumstances, and may be enjoyed in every situation in which a man may be placed in life."—HERSCHEL, *on the Study of Natural Philosophy.*

THESE beautiful volumes contain more than 1000 pages of about 1200 letters to a page; and they are printed in the best style of London typography, with fine paper and a great number of illustrations contained in seven copper-plate engravings exquisitely done and colored, and 167 wood-cuts of unrivalled beauty. The latter are called by the author *lignographs,* and *lign.* as the abbreviation. The work is dedicated to the eminent geologist, Charles Lyell, Esq., the author's early friend.

In his address to the reader, Dr. Mantell states, that his great object has been to produce a work which shall "initiate the young and uninstructed in the study of the MEDALS OF THE CREATION—those electrotypes of nature—the mineralized remains of the plants and animals which successively flourished in the earlier ages of our planet, in periods incalculably remote, and long antecedent to all human history and tradition." These volumes are offered "as a guide for the student and the amateur collector; for the intelligent reader, who may require a general knowledge of the subject, without intending to pursue geology as a science; and for the tourist, who may wish, in the course of his travels, to employ profitably a leisure hour in quest of those interesting memorials of the ancient physical revolutions of the globe, which he will find every where presented to his observation."

"In the arrangement, a threefold object was had in view, namely, in the first place to present such an epitome of paleon-

tology, or the science which treats of the fossil remains of the ancient inhabitants of the globe, as shall enable the reader fully to comprehend the nature of the principal discoveries in modern geology, and the method of investigating natural phenomena, by which such highly interesting and unexpected results have been obtained."

"Secondly, to assist the COLLECTOR in his search for organic remains, direct attention to those objects which possess the highest interest, and are especially deserving of accurate examination, instruct him in the art of developing and preserving the specimens he may discover, and point out the means to be pursued for ascertaining their nature and their relation to existing animals and plants."

"Thirdly, to place before the STUDENT a familiar exposition of the principles of paleontology, based upon a knowledge of the structure of vegetable and animal organization; excite in his mind a desire for further information, and prepare him for the study of works of a far higher order than these unpretending volumes; and point out the sources from which the required instruction may be derived."

The above quoted passages contain the author's own account of his design. The following will explain his views as to the use to be made of his work, according to the quaint but wise advice contained in the following sentence of Lord Bacon, the father of the inductive philosophy.

"Some are to be tasted, others to be swallowed, and some few to be chewed and digested; that is, some books are to be read only in parts; others to be read, but not curiously; and some few to be read wholly, and with diligence and attention."—*Essays.*

To the *tasting student,* the author recommends "the perusal of the introductory and concluding remarks of each chapter, and of the general descriptions," reserving the work to be consulted as occasion may require. It must be *swallowed*—that is, read, but not curiously, by him who would form and understand a collection of organic remains; but by the student who would profit by it to the utmost, it must be diligently studied and digested. Organic remains must be studied, not only in the book, by the figures and descriptions, but *in situ* in the rocks, mines, caverns, and transported masses, and thus the labor will be rendered both

available and delightful; for the observer will "walk in the midst of wonders in circumstances where the uninformed and uninquiring eye can perceive neither *novelty* nor *beauty*."*

In his introduction, the author explains the object of the science of geology, and quotes Sir J. F. W. Herschel's remarks, that "geology, in the magnitude and sublimity of the objects of which it treats, undoubtedly ranks next to astronomy in the scale of the sciences." And again, speaking of the studies of natural science, that "the highest worldly prosperity, so far from being incompatible with them, supplies additional advantages for their pursuit; they may be alike enjoyed in the intervals of the most active business, while the calm and dispassionate interest with which they fill the mind, renders them a most delightful retreat from the agitations and business of the world, and from the conflict of passions, prejudices, and interests, in which the man of business finds himself continually involved."

The author alludes to the incredulity which existed in England, even so late as a century ago, when it was doubted whether fossil shells were really shells, and it was seriously believed that subterranean spirits, jealous of man's intrusion into their dark domains, broke the augurs of the miners; but it is fair also to say, that Dr. Martin Lester, who died one hundred and thirty two years ago, having been physician to Queen Anne, published a valuable work on fossil shells, describing them as real animal productions; he was also well acquainted with the chalk and with the other strata of the south of England. The author presents, *in limine*, the following conclusions, startling to uninstructed minds, but admitted by all geologists,—"that the sea and land are continually changing places; that what is now dry land was once the bottom of the deep; and that the bed of the present ocean will, in its turn, be elevated above the water and become dry land; that all the solid materials of the globe have been in a softened, fluid, or gaseous state; and that the remains of countless myriads of animals and plants are not only entombed in the rocks and mountains, but that every grain of sand and every particle of dust wafted by the wind, may teem with the relics of beings that lived and died in periods long antecedent to the creation of the human race."

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* Sir John F. W. Herschel's Discourse, Nat. Philos., p. 15.

In regard to "the great benefits resulting from scientific pursuits in general, and of geology in particular, on the young and inquiring mind," the author cites the following observations of an able modern writer.

"It is fearfully true, that nine tenths of the immorality which pervades the better classes of society originates, in the first place, from the want of a harmless and pleasing occupation to fill up vacant time; and as the study of the natural sciences is as interesting as it is beneficial, it must necessarily exert a moral not to say religious influence upon the character. He who is fond of scientific pursuits will not enter into revelry, for artificial excitements have for him no fascinations. The overflowing cup, the unmeaning or dishonest game, cannot entice him. If any one doubts the beneficial influence of these studies on the morals, I will ask him to point out the immoral young man who is devotedly fond of any branch of natural science; I never knew such an one. There may be such individuals—for religion only can change the heart—but if there be, they are very rare exceptions; and the loud clamor always raised against the man of science who errs is a proof of the truth of my proposition—the ennobling study of God's works upon a well regulated mind. Fortunate, indeed, is it for the youth of either sex, who early imbibes a taste for natural objects, and whose pursuits are not thwarted by injudicious friends."

The author adds in his own beautiful language, that "every grain of sand, every particle of dust scattered in the wind, may be composed of the petrified skeletons of beings so minute as to elude our unassisted vision, yet were once teeming with life and happiness, and possessed an organization as marvellous as our own; a science whose discoveries have realized the wildest imaginings of the poet—whose realities far surpass in grandeur and sublimity the most imposing fictions of romance; a science whose empire is the earth, the ocean, the atmosphere, the heavens; whose speculations embrace all elements, all space, all time; objects the most minute, objects the most colossal, carrying its researches into the smallest atom which the microscope can render accessible to our visual organs, and comprehending all the discoveries in the boundless regions above us which the most powerful telescope can reveal." "None of the physical sciences can more strongly impress on the mind that deep sense

of humility and dependence which a proper knowledge of the works of the Eternal is calculated to inspire, so none can more powerfully encourage our aspirations after truth and wisdom. Every walk we take offers subjects for permanent consideration, and contemplating the innumerable proofs afforded us of the incessant dissolution and renovation which are taking place around us, we feel the force, the beauty of the exclamation of the poet—

> " 'My heart is awed within me when I think
> Of the great miracle which still goes on
> In silence round me—the perpetual work
> Of thy creation, finished, yet renewed
> Forever.' "

We have chosen to allow the author to be his own expounder of the design of his work, and have therefore quoted freely his introductory remarks and those of the friends whose sentiments he adopts. Among the authorities to which he refers, the following are conspicuous:

1. Dr. Buckland's Bridgewater Treatise, 2 vols. 8vo. 2. The Elements of Geology, by Charles Lyell, Esq., second edition. 3. The Wonders, or a familiar Exposition of Geological Phenomena, by Dr. Mantell. 4. Phillips' Mineralogy.

All these works he considers as well known in England, and easily accessible, and happily this is true here also, as all of them have been republished in this country, as also Mr. Lyell's Principles of Geology, and a greatly improved edition of Phillips' Mineralogy by Mr. Alger, has recently appeared in Boston.*

A glossary of terms is appended to the work, and technical terms are explained in the text, but generally without citing the original words, especially Latin or Greek, an omission which we regret, as to the classical scholar nothing imparts so distinct and vivid a conception of the import of a technical term as the parent word, and upon these hooks of the memory it is easy to hang long trains of associated ideas.

The divisions of the work are as follows.

Part I.

1. On the nature and arrangement of the British strata and their fossil contents.

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* For a review of the last mentioned work, see this Journal, Vol. xlvii, p. 333.

2. Tabular chronological arrangement of the strata.
3. On the nature of fossils and organic remains.
4. On mineralized vegetable remains, and the mode of conducting their investigation.
5. On peat, lignite, and coal.
6. Fossil botany.
   - *a.* Remains of the Cellular and Cryptogamic plants.
   - *b.* " " Vascular Cryptogamia.
   - *c.* " " Filicites or Ferns.
   - *d.* " " Sigillariæ and Stigmariæ.
   - *e.* " " Lepidodendra.
   - *f.* " " Cycadeous plants.
   - *g.* " " Coniferæ.
   - *h.* " " Palm tribe.
   - *i.* " " Liliaceous plants.
   - *k.* " " Flowering dicotyledons.
   - *l.* Retrospect, and list of localities of vegetable fossils.

Part II.

Palæontology, or the fossil remains of the animal kingdom.

1. The fossil infusoria, or animalculites.
2. Polyparia and other Zoophytes.
3. Echinodermata, comprising
   - (1.) The Crinoidea, or lily-shaped animals.
   - (2.) The Stelleridæ, or Star-fish.
   - (3.) The Echinidæ, or Sea-urchins.
4. Fossil Mollusca, or Shells.
5. Crustacea and Insects.
6. Fishes.
7. Reptiles.
8. Birds.
9. Mammalia.

Part III.

1. Geological excursions in illustration of the investigation of geological phenomena and the collection of organic remains.
2. Miscellaneous. On the prices of fossils, list of dealers, localities, &c.

To each volume there are, of course, prefixed lists and descriptions of the plates and wood-cuts, (lignographs, or inscriptions on wood,) and detailed contents of the chapters. The index is

conveniently distributed under three divisions—viz. index of scientific names, index of places, index of matters in general.

Thus we have presented the author's own map of his subject, and rarely can we find a work which is a more perfect example of the art of book-making in the best understanding of that appellation; we mean technically and mechanically, as well as intellectually, "The Medals of the Creation" are among the *chef d'œuvres* of the art, and the two volumes being elegantly bound in stamped and embossed covers, of the still portable size of the larger 12mo, will and must take their place as the companions, not only of the geologist in his study, but in the field, while they will also accompany the general travellers of both sexes as most instructive companions and mentors in their journeys among the grand and beautiful features of the globe.

The Wonders of Geology, by Dr. Mantell, a work already well known to our readers, is about to appear in a new edition, and this with the Medals will form four uniform volumes, and the two works will mutually illustrate each other.

From chapter first of the Medals, "on the nature and arrangement of the British strata and their fossil contents," we make the following citations.

The globe consists of minerals and fossils; minerals are formed by chemical or electro-galvanic laws—fossils are the remains of animals and vegetables imbedded in the strata, and more or less altered by physical laws. The softer parts are usually decomposed soon after death, but the firmer structures, such as the bones and teeth of animals, and the woody fibre of vegetables, often endure for many centuries; and, in favorable circumstances, as with deep interment, away from the atmosphere, and when impregnated with mineral substances, even the most perishable tissues are preserved, and being transformed into stone they become as enduring as the rocks themselves, of which they often form a principal part.

Certain animal substances are even more enduring than vegetable; and the shields of animalcules, composed of silica, or flint, (or iron?) become absolutely indestructible, and exist in such inconceivable quantities as almost to justify the apparently extravagant assumption of some naturalists of the last century, "that every grain of flint, lime, and iron, may have been elaborated by the energies of vitality."

The following table, showing how large a portion of the globe has unquestionably originated from this source, will probably appear very surprising to those who have not examined the evidence. The order is from below ascending, and the enumeration begins with the Silurian system, which follows immediately after the early slaty rocks, and the entire series occupies in England, as well as in other countries, many thousand feet.

ROCKS COMPOSED WHOLLY OR PARTLY OF ANIMAL REMAINS.

Strata.	*Prevailing fossils.*	*Formations.*
Trilobite schist,	Trilobites and shells,	Silurian system.
Dudley limestone,	Corals, crinoidea, shells and trilobites.	
Shelly limestone,	Productæ, spiriferæ, &c.	
Mountain limestone,	Corals and shells,	Carboniferous system.
Encrinital marble,	Lily-shaped animals and shells.	
Mussel band,	Fresh-water muscles.	
Ironstone nodules,	Trilobites, insects, and shells.	
Lias shales and clays,	Pentacrinites, reptiles, fishes,	Lias.
Limestone,	Terebratulæ and other shells.	
Lias conglomerates,	Fishes, shells, corals.	
Gryphite limestone,	Shells, principally gryphites.	
Limestone,	Terebratulæ and other shells,	Inferior oolite.
Stonesfield slate,	Shells, reptiles, fishes, insects.	
Pappenheim schist,	Crustacea, reptiles, fishes, insects.	
Bath-stone,	Shells, corals, crinoidea, reptiles, fishes.	
Limestone,	Cephalopodæ, principally ammonites.	
Coral rag,	Corals, shells, echini, ammonites.	
Bradford limastone,	Crinoidea, shells, corals, cephalopoda.	
Portland oolite,	Ammonites, trigoniæ, and other shells.	
Purbeck and Sussex marble,	Fresh-water shells, crustacea, reptiles, fishes,	Wealden.
Wealden limestone,	Cyclades, and other fresh-water shells, crustacea, reptiles, fishes.	
Tilgate grit, some beds,	Reptiles, fishes, fresh-water shells.	
Farringdon gravel,	Sponges, corals, echini, and shells,	Shanklin sand.
Jasper and chert,	Shells, sponges, and animalcules.	
Green sand,	Fibrous zoophytes.	
Chalk,	Corals, infusoria, echini, shells, fishes,	Chalk.
Mæstricht limestone,	Corals, shells, ammonites, belemnites, and other cephalopoda, reptiles,	Chalk.
Hippurite limestone,	Shells, principally hippurites.	
Hard chalk, some beds,	Echini and belemnites.	
Flints,	Sponges, and other fibrous zoophytes, infusoria and spines of zoophytes, echini, shells, corals, crinoidea.	
Limestone,	Fresh-water shells,	Tertiary.
Nummulite rock,	Nummulites.	
Septaria,	Nautili, turritellæ and other shells.	
Calcaire grossier,	Shells and corals.	

Strata.	*Prevailing fossils.*	*Formations.*
Gypseous limestone,	Mammalia, palæotheria, &c., birds, reptiles, fishes.	
Siliceous limestone,	Shells.	
Lacustrine marls,	Cyprides, phryganeæ, fresh-water shells.	
Monte Bolca limestone,	Fishes.	
Bone breccia,	Mammalia and land shells.	
Sub-Himalaya sandstone,	Elephant, mastodon, &c., reptiles.	
Tripoli,	Infusoria.	
Richmond marl,	Animalculæ and infusoria.	
Semi-opal,	Infusoria.	
Mountain meal,	Infusoria.	
Guadaloupe limestone,	HUMAN skeletons, land-shells, corals,	Human epoch.
Bermuda limestone,	Corals, shells, serpulæ.	
Bermuda chalk,	Comminuted corals, shells, &c.	
Bog iron ore,	Infusoria.	

To this list may be added peat grounds, swamps and morasses abounding with animalcules, both living and fossil.

When it is understood that several miles in depth of the crust of the earth are replete with the remains of organized beings, and that numerous beds of great thickness are composed almost entirely of them, we cannot wonder that a distinct work has been written for these astonishing medals of the creation. The vegetable world has also furnished its quota to form the solid crust of the world.

"Immense tracts of country are composed almost wholly of the remains of plants in the state of anthracite coal, lignite, and brown coal; of submerged forests and peat mosses; and of layers of trees and rocks transmuted into siliceous and calcareous rock. Organic remains are found in almost every sedimentary deposit of whatever kind; but they abound much more in some than in others, or are found more abundantly in particular parts of the rocks, or are peculiar to certain rocks, some being peculiar to the most ancient, others to the more modern, 'while some genera range through the entire series of rocks, and also appear as denizens of the existing *lands and seas.*' Hence they acquire a high degree of interest, as they inform us of 'the physical condition of our planet in the most remote ages,' and 'they are chronometers of the successive revolutions which the surface of the earth has undergone.' By their aid, 'the relative age of a formation or group of strata may be determined, as well as the mode of its deposition and the agency by which it was effected;

whether in the bed of an ocean or of a lake or estuary—by the action of the sea or of rivers—of lakes or of running streams—by the effects of icebergs or glaciers—by slow processes through long periods of time, or by sudden inundations or deluges, or by the agency of volcanoes and earthquakes."

Dr. Mantell remarks that the entire series of rocks within the scope of human examination, is estimated at a thickness of from fifteen to twenty miles, reckoning from the summit of the highest mountains to the greatest depth hitherto penetrated; and as this thickness scarcely equals $\frac{1}{400}$th of the diameter of our globe, it is familiarly termed the earth's crust.

We are pleased to observe that the allowed thickness of the earth's known crust is here taken at about twice what it was formerly estimated, but including the knowledge which we gain from the inclination of the strata and from the ejection of ancient and modern igneous masses, there can be no doubt that we understand its constitution to a much greater depth, even hundreds of miles.

The author divides the fossiliferous rocks into

1. "The tertiary; comprising all the deposits from the alluvial drifts to the chalk.

2. "The secondary; from the chalk to the old red, or Devonian system, inclusive.

3. "The Silurian; from below the Devonian to the upper part of the Cambrian system, in which all traces of organic remains disappear."

The second chapter contains the classification of the stratified rocks upon, 1, their mineral structure; 2, their order of superposition; and 3, the nature of the organic remains they contain.

The great and subordinate divisions correspond with those in general use among English geologists: we cite only the leading members.

I. Drift, ancient and modern.

II. The Tertiary system, with its Pliocene, Miocene and Eocene.

III. The Chalk, with seven subdivisions.

IV. The Wealden, with four subdivisions.

V. The Oolite, with five greater and sixteen lesser subdivisions.

VI. The Lias, with four subdivisions.

VII. The Saliferous, or New Red Sandstone—two principal and eight inferior divisions.

VIII. The Carboniferous—three principal and seven inferior divisions.

IX. The Devonian, or Old Red system—two divisions.

X. The Silurian system—two principal and five subdivisions.

XI. The Cambrian, or Schistose system—three subdivisions.

XII. Hypogene rocks.

Metamorphic—two divisions.

XIII. Plutonic.

XIV. Volcanic rocks—two divisions.

It will be observed that the peculiar province of this work ceases with division XI, and nearly with X. No rocks below these have been proved to be fossiliferous, and the inferior region is the domain of the rocks of fire, in which had there ever been any fossil bodies embraced, they would have been obliterated.

In his third chapter, the author cautions collectors against throwing away shells, bones, &c., because they appear little altered—for they may be in that condition even in very ancient strata—shells retaining their pearly lustre, and even their ligaments; and on the other hand, in very recent formations they may be completely silicified, or otherwise mineralized. He warns his reader also against mistaking incrustations for petrifactions; depositions of lime, for example, often take place in mineral springs, which merely enclose the foreign body without altering its nature, and some of these things are prepared by art, as birds' nests, and even the birds themselves.

Dr. Mantell, after pointing out the peculiarities of fossil bones, gives copious and excellent directions for extracting them, reuniting their dissevered parts, and preserving them; and surely no man has a better right to speak on this subject than he, for he has been singularly industrious, persevering, and sagacious, in discovering and bringing into union the fragments of skeletons, especially of the huge Iguanodon, his own fossil wonder.

The introduction to the history of fossil vegetables is brief, graphic, and lucid, and from it we cite the following passages.

"The remains of the vegetable kingdom are presented to the notice of the geologist, in various conditions; in some instances but little changed in their aspect, as in the recent accumulations of mud and silt at the bottom of lakes and rivers, and in mo-

rasses and peat bogs; in tufaceous incrustations, as decayed wood, with the imprints of the leaves and stems preserved on the solid masses of concretionary or crystalline limestone."

"In the ancient deposits vegetables are found in two different states. In the one, their substance is completely permeated by mineral matter; it may be calcareous, (lime,) siliceous, (flint,) ferruginous, (iron,) or pyritous, (sulphuret of iron;) and yet both the external characters and the internal structure may be preserved. Such are the fossil trees of the Isle of Portland, fragments of which so closely resemble decayed wood, as to deceive the casual observer, until by close examination of their texture and substance he finds that they possess the weight and hardness of stone. In the silicified wood, (that petrified by silex or flint,) which abounds in many of the tertiary strata, the most delicate tissue of the original is generally preserved, and by microscopical examination may be displayed in the most distinct and beautiful manner. Calcareous wood also retains its structure, and in many limestones leaves and seed-vessels are well preserved."

"The ligneous coverings or the husks and shells of muciferous fruits, or the cones and strobili of firs and pines, are frequently in an excellent state of preservation; and in some rare instances indications of flowers have been observed. The parts of fructification in some of the fern tribe occur also in coal shale, and in the grit of Tilgate Forest; and even the pollen of Coniferæ has been found in tertiary marls associated with animalculites. The resinous secretions of pines and firs are also found in a mineralized state. Amber is too well known to require any further mention in this place, than that its vegetable nature is unquestionable; this substance has been observed in its natural position in trunks of Coniferæ. The fossil resin of the London clay, discovered at Highgate and the Isle of Sheppey, had a similar origin." * * * "The diamond, which is a pure charcoal, is probably a vegetable secretion that has acquired a crystalline structure by electro-chemical action." * * *

"But vegetables occur not only in petrified stems, leaves, and fruits, associated with other remains in the strata, but in beds of great thickness and extent, consisting wholly of plants transmuted, by that peculiar process which vegetable matter undergoes when excluded from atmospheric influence and under great pressure, into carbonaceous masses called lignite and coal. And there

are intermediate stages of this process, in which the form and structure of the plants are apparent, and a gradual transition may be traced from the peat-wood and submerged forests of modern epochs, in which leaves, fruits, and trunks of indigenous species are preserved, to those accumulations of the extinct species of an ancient flora, whose vegetable origin the eye of science alone can detect."

The author points out the distinction between cellular and vascular structure; the most simple plants have a cellular tissue, consisting of a series of cells of the same kind, having no visible fructification; such are sea-weeds, (Algæ, Confervæ, &c.) mosses and lichens. In the more complex tribes, the cells are elongated into tubes or vessels, (vascular tissue,) some of which possess a spiral structure, and others have their sides studded with little glands, &c.

The microscope, when applied to thin slices of fossil wood, is of great service in developing their structure, and thus revealing their nature. In this manner it is ascertained whether the tree were endogenous, (increasing by expansion from within, and having seeds with a single lobe,) or exogenous, (increasing by annual additions on the outside of the wood beneath the bark, and having seeds with two lobes, &c.) We cannot, in a brief notice, follow the lucid explanations of the author, illustrated by his beautiful figures, nor can we quote his excellent directions for the microscopical examination of fossil plants.

In writing of submerged forests and their long endurance, he informs us that "the oak timbers of the Royal George, lately raised from off Portsmouth, after being immersed in silt about sixty years, closely resemble in color and texture the sound wood of the submerged forests."

In the peat bogs of Ireland, large forest trees are often buried with the skeletons of elk, deer, and other animals of the chase, and the primitive hunters with them wrapped in skins.

In the celebrated Bovey coal of England, the wood as far as observed by Dr. Mantell is coniferous, and is easily split or chipped; the layers of coal are from one foot to three feet thick, and eighteen or twenty beds occur in a depth of about one hundred and twenty feet; this field of lignite extends seven or eight miles.

In Iceland, although living wood is rare, beds of lignite called Surturbrand abound. Jet is a compact lignite. It is abundant

in the cliffs of alum shale on the coast of Yorkshire. The stump of a tree in a cliff, three feet in diameter by fifteen long, was found to be jet in the roots, which were encased in shale, while the trunk, being in sandstone, was silicified, and part of the wood was in decay, having escaped the mineralizing process. Vegetable remains enclosed between beds of clay are peculiarly prone to be converted into coal—the gaseous elements being imprisoned by the tenacious investing substances. Dr. Mantell fully sustains the theory of the vegetable origin of coal, which indeed no thorough student of the facts ought to doubt.

"It is estimated that scarcely one thousand species of plants have been discovered in a fossil state, while the known recent species amount to nearly one hundred thousand." *Confervites*, which are cellular and aquatic plants, "are found sometimes in transparent quartz pebbles."

Some of the fossilized Calamites (resembling horse or mare's tails) are from one foot to three feet in diameter; they were very numerous in the coal formation. The largest species of modern British ferns scarcely exceed four or five feet in height, but the tree ferns of warm climates are sometimes thirty to forty feet high, thus resembling the ferns of the coal period. There are more than 2000 species of living ferns, while those hitherto found in the fossil state exceed 150. Of the Pecopteris or embroidered fern, the most abundant fern in coal, leaves have been found 4 feet wide, and of a proportionate length.

A few years since, in forming the Bolton and Manchester railway, five stems or trunks of Sigillariæ were found standing as they grew, the largest 11 feet high and 7½ in circumference at the base. In Derbyshire in 1838, in forming a railway five miles from Chesterfield, they encountered a grove of nearly 40 Sigillariæ, standing not more than 3 or 4 feet apart and at right angles to the strata. In Nova Scotia, on the southern shore of the Bay of Fundy, in cliffs about 2000 feet high of the coal formation, are ten rows of trees, (Sigillariæ,) one row above another, proving as many distinct surfaces of the ground, and as many submergences.*

Sigillariæ vary from a few inches to 5 feet in diameter, and from 5 to 50 feet in height. The Sigillariæ in the opinion of

* Mr. Lyell, in this Journal, Vol. XLV, p. 353.

M. Adolphe Brongniart were Coniferæ, resembling externally *Cacteæ* or *Euphorbiæ*, but in internal organization *Zamiæ* or *Cycadeæ*. Near Liverpool, (Eng.) there has been discovered an upright trunk of a Sigillaria 9 feet high, with its roots 8 or 9 feet long, and still attached in their natural position. These roots prove to be what have been usually called *Stigmaria fucoides*, and their radicles have been regarded as leaves. Sigillariæ and Stigmariæ are therefore identified—the former being the stem and the latter the roots.

The Lepidodendra are considered as gigantic club mosses and ground pine; there are about 200 living species, and they are most of them creeping plants, and none exceed 3 feet in height. A fossil Lepidodendron was found in the Jarrow colliery, Durham County, England, 40 feet high, and 13 feet in diameter, (circumference?—Eds.) divided into 15 to 20 branches.

In the famous Portland fossil forest, silicified Cycadeæ are found standing erect where they grew, between rows of petrified fir trees—an entire forest of pines, whose silicified roots are still engaged in the mould in which they once flourished.

"In the sands of the desert of Sahara, in Egypt, among the mammalian bones of the Sub-Himalayas, and in the tertiary deposits of Virginia, associated with Cycadeæ,—drifted coniferous wood and stems have been discovered."

Fossil forests, silicified or calcareous, are found in Van Diemen's Land and Australasia, standing erect to the height of several feet, apparently in the places in which they grew, their roots in dry sand, their petrified branches and stems being scattered around, and the calcareous fossil trees have been burned into lime for manuring the ground.

A fossil pine forest exists on the eastern coast of Australia. Stumps of silicified trees project from the ground like a forest all whose trees have been cut down to the same level. At the distance of some yards from the shore, there is a reef composed of the petrified stumps of silicified trees projecting vertically in rows above the water to the height generally of 3 or 4 feet, and they are from 2 to 6 feet in diameter, and from 60 to 120 annual rings were counted in some of them. In the vicinal hills, beds of lignite occur, both above and below the fossil trees, and there are several localities in Australia where similar phenomena are presented.

Palm trees are often found petrified—the date and cocoanut belong to this family. A forest of palms is described by Dr. Owen as occurring in Indiana in a member of the Illinois coal-field; 20 or 30 trees were found with their roots in the clay, and their stems in the coal and sandstone above, apparently in the place where they grew;* the form of the seeds left by the petioles in the now carbonized bark indicates at least three species of palms.

Silicified stems, probably related to palms, are very widely distributed, and have been collected among the mammalian remains in Asia and in the Sub-Himalayan mountains.

Lignite is composed almost entirely of dicotyledonous trees belonging to genera, and in many instances to species, namely, poplar, willow, elm, chestnut, walnut, sycamore, maple, linden, beech, thorn, &c. which are still inhabitants of Europe. The lignites of the Rhine are the carbonized remains of drifted forests like the rafts of the Mississippi, which may hereafter, in their turn, become lignite.

Silicified dicotyledonous trees are numerous in the Egyptian and Lybian desert. About seven miles east by south from Cairo a petrified forest lies in ruins, like an overturned modern forest—the trunks crossing each other in various directions. Two of the largest measured 48 and 60 feet in length, and 2½ to 3 feet in diameter at the base. This forest reposes on a platform of marine limestone, once the bed of the ocean, but now higher than the level of the Nile. Vegetable matter occurs in all the eras of fossil deposits. It is probable that many families, from their delicate structure and from other causes, have entirely perished; those that have been discovered are naturally distributed under three groups.

1. The earliest, including the carboniferous, consists chiefly of fuci, ferns, Coniferæ, Lycopodiæ, and other families, analogous to the vegetation of the islands and archipelagos of tropical climates.

2. The middle epoch—from the new red sandstone to the chalk—contains, prevailingly, Cycadeæ, Zamiæ, and other Coniferæ; ferns are rare, and Lycopodiæ and Calamites of the coal period are wanting. The flora is analogous to that of the maritime districts of New Holland and Cape of Good Hope.

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* This Journal, Vol. XLV, p. 336.

3. In the tertiary above the chalk, dicotyledonous trees are frequent, Cycadeæ are rare, ferns not numerous, and Coniferæ more common; corresponding with the general features of our continental floras. In the secondary formation, the grasses are almost entirely absent.

Fossil Zoology.—The recent species of animals exceed 100,000, while those found fossil scarcely amount to 10,000, but still the latter comprise most of the classes and families, and many of the genera and species of the existing animal races.

The divisions adopted by Dr. Mantell are—

I. Infusoria, or *animalcules.*

II. Zoophytes, including, 1. Amorphozoa, or *animals with irregular forms.* 2. Polyparia, or *coral animals.*

III. Echinodermata, *animals with a spiny skin,* comprising
- 1. Crinoidea, or *lily-shaped animals.*
- 2. Asteria, or *star-fishes.*
- 3. Echinidæ, or *sea-urchins.*

IV. Mollusca, (*animals with soft bodies,*) including shell-fishes.
- 1. Bivalves; the *Brachiopoda* and *Lamelli-branchia.*
- 2. Univalves; the *Gasteropods.*
- 3. Chambered Shells; the *Cephalopods,* including the testaceous genera, and those destitute of shells, as the *Sepiadæ,* or cuttle-fish.

V. Articulatæ, (*having external jointed cases or skeletons,*) comprising
- 1. Cirripedia; as the *barnacle.*
- 2. Annelata, or *red-blooded worms.*
- 3. Insectæ, or *insects;* and *Arachnidæ,* or *spiders.*
- 4. Crustacea, (*having a crustaceous skin,*) as crabs and lobsters.

VI. Pisces, or *fishes.*

VII. Reptilia, or *reptiles.*

VIII. Aves, or *birds.*

IX. Mammalia, (*animals giving suck.*)

That the microscopic animalcules of our waters should be found fossil, forming hills and the subsoil of large districts, and that colossal monuments should be constructed by man of the mineralized remains of animalcules invisible to the naked eye, is not more wonderful than true.

Every where the tertiary, cretaceous, and other secondary deposits are replete with fossil animalcules, the study of which, with the aid of the microscope, can be pursued quietly at home. Prof. Ehrenberg of Berlin led the way, and Prof. Bailey of West Point has successfully followed, in these brilliant investigations, in which others also are engaged.

A cubic inch of the marine sands of the Paris basin is calculated to contain 60,000 *foraminifera* and *infusoria.* The statement is now familiar that the polishing slate of Bilin contains in a cubic inch 41,000,000,000 of animalcules, (*Gaillonellæ.*) In Lapland, a similar earth is mixed with ground bark of trees for food. The infusorial marls of Petersburg and Richmond, Va. are rich in fossil animalcules of great variety, elegance, and interest; and we may add, that the city of Charleston, S. C., stands (as recently ascertained by Prof. Bailey) upon immense beds of animalcules. In the northern seas there are minute animals "precisely similar to those which lived in a much lower latitude at some remote period."

"It has long been known that a large proportion of the present white chalk consists of minute chambered shells and corals," and Ehrenberg has now shown, "that each cubic inch of chalk may contain upwards of one million of well preserved animalculites and shells." "Numerous shells, corals, and infusoria of the most ancient cretaceous deposits, are identical with existing species; in the sea-water of Cuxhaven, &c. 21 genera and 40 species are found, differing in no respect from fossils that occur in chalk." The compact crystalline marble of the Pyrenees is replete with nummulites, and the great pyramid of Egypt is composed of them, with a cement of microscopic animalculites; and a range of mountains near Suggsville, U. S., 300 feet high, is composed entirely of one species of nummulite.* A large portion of the sand of the Lybian desert is composed of fossil animalcules; and as they are found more or less in all the secondary strata, it is proved that they have contributed largely to the formation of the present crust of the planet.

Zoophytes.—They were so called from a false impression that they were plants having an animal nature, whereas their animal

* Dr. Morton.

character is now fully established.* The zoophytes have also afforded an immense amount of materials towards forming the present habitable earth. In the most ancient fossilized strata, zoophytes hold a conspicuous place, and in the warm climates they are now performing wonders in constructing the foundations of immense coralline reefs, to become, in due time, habitable islands and populous continents.

We have no space to cite the author's beautiful account of fossil sponges and Alcyonia, many of which we are so happy as to possess, through his liberality, but we must refer to the MEDALS for a full account of this family, which is rendered very intelligible by his fine illustrations and lucid philosophy. For the same reason, and also because we are soon to have an original work on this subject from Mr. Dana, the geologist of the American south polar expedition, we must dispose of the magnificent family of the corals in very brief terms. "The detritus of numerous minute and elegant calcareous Polyparia constitutes a considerable portion of the mass of some of the cretaceous beds." The Gorgonia or Venus' fan is occasionally met with in the fossil state.

Such is the close resemblance of the stony Polyparia to existing species, that "every pore and cell might be represented fraught with life; here, the agile inmates, fully expanded, with their little arms or tentacula, in rapid motion; then retreating within their recesses and devouring the infinitesimal living atoms that constitute their food, or rapidly sinking to the bottom of their cells upon the approach of danger; even their varied colors might be introduced, and thus a beautiful and highly interesting picture be presented to the eye, as now to the imagination." Corals were abundant in the early fossiliferous rocks. "A slab of Derby limestone (Eng.) often has the entire surface studded with corals, shells, and crustaceous animals of many species and genera, lying in bold relief, and in the most beautiful state of preservation."

"Nearly 350 species of zoophytes are enumerated in Mr. Morris's catalogue of British organic remains." The Silurian rocks of North America present the same coral formations as those of

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* If there be a doubt it is in regard to the sponges, which as the author intimates may be regarded as true animal plants,—a connecting link between the two kingdoms.

England; and it is inferred that a very equal warm temperature must at an early epoch have pervaded the globe, whereas "the reef-forming genera of corals are now confined to waters where the temperature is not below 70°; their most prolific development being 76°."*

The fossil Echinodermata (*spiny-skin animals*) are found among the earliest traces of animal existence; the Crinoidea abound in the Silurian system, and one species of Stelleridæ has been there found.

These animals have a radiated structure around a common centre, of which the sea-urchin or hedgehog, and the star-fishes of our sea-coasts are familiar examples. In most cases the skin is protected by spines—whence their name; and there are minute foraminæ for the admission of sea-water or the protrusion and retraction of minute tubes or hollow tentacula, which constitute their common organs of adhesion and locomotion.

In England, in North America, and many other parts of the world, entire mountain chains are composed chiefly of the bones of Crinoidea. "The Crinoidea may be regarded as star-fishes, fixed to one spot by a jointed stem; the star-fishes are free Crinoidea."

The British species of Crinoidea exceed 130; the skeleton of an individual lily encrinite is composed of more than 26,000 pieces or little bones, and a single pentacrinite of upwards of 150,000, so that the number and variety, and we may add, beauty of these fossils will no longer appear marvellous.

Fossil Echini have not been observed in the Silurian system; but the Cidaris appear in the carboniferous. In the lias, Echini begin to prevail with Stelleridæ and become abundant in the oolite and chalk. In the marine tertiary they are as numerous as in the modern deposits. In the British strata nearly 100 Echini have been obtained, almost all of extinct species, while hardly 20 species of star-fishes have been observed.

The Fossil Mollusca are (except the animalcules) by far the most numerous and various family of organic remains. To the mere amateur conchologist, shells are objects of great interest on account of their beautiful forms and colors, but few collectors are conversant with the nature of the animals that secreted and

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* Or between 72° and 80°; different corals probably are favored by different temperatures.—Eds.

inhabited these elegant and enduring structures; even those so commonly eaten (as for example oysters and clams) are regarded as shapeless gelatinous masses,* yet they are the very beings that secreted and formed the lustrous and symmetrical shells, and are indeed objects of the highest interest to the naturalist.

"To the geologist, from their permanent nature and the proofs they yield of the conditions under which the strata that contain them were deposited, they are important in the highest degree; and geological formations have been classified from the shells they contain, and from their numerical proportion in different groups of strata; witness the *Eocene*, *Miocene*, and *Pliocene* of Mr. Lyell."

The Gasteropoda (*feet under the body*) are very widely distributed. The garden snail is a familiar example of a terrestrial Gasteropod.

Among the Cephalopoda (*feet around the head*) the cuttle fishes have no shell but an internal skeleton or sheath; in all the other mollusca the head parts are external. Some of the mollusca have a retractile proboscis armed with minute teeth, by which they can rasp or bore into the shells of the species on which they prey.

The number of known living mollusca exceeds 6,000.

"The Pectens, unlike the oysters, have the power of locomotion, and may be seen moving with rapidity, and flapping their shells to and fro with great activity. Numerous species are found fossil." "Of the Conchifera, or bivalve shells, nearly 800 species are known in Great Britain."

The Gasteropoda have a head and mouth, with jaws, eyes, and feelers; and they generally creep by means of a fleshy disk or foot, which is situated under the belly. The greater number are marine, but some live on trees, or in rivers or streams, or in stagnant and brackish waters. The common snail, river snail, and periwinkle, are instances of terrestrial, fluviatile, and marine forms.

The number of Gasteropods in the British strata is nearly 800, distributed through the sedimentary formations from the Silurian to the newest tertiary, in which the greater proportion is found. Dr. Mantell has given the name of *molluskite* to a dark matter

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* "You shapeless nothing in a dish,
You that are but almost a fish."
Cowper's Oyster and Sensitive Plant.

occurring in certain marbles, as the Sussex and Purbeck; the fetid emanations produced by friction upon certain limestones is due to animal matter.

Cephalopods.—Dr. Buckland's restoration of the Belemnite under the name of Belemno-sepia* has been fully sustained by the discovery in the Oxford clay, near Chippenham, England, "not only of several examples with the osselet, receptacle and ink-bag in their natural relative positions, but also with the remains and impressions of the mantle, body, tentacula,—with their hooks or clasps, and the fins!" From these remains they have been able to draw the figure of the once living animal, with all the appendages true to nature. The fossil ink-bag is sometimes large; they have been found a foot in length, and it is inferred that the animals were suddenly buried in mud and died instantly,—otherwise the ink would have been ejected, and the membrane would have been destroyed by decomposition.

In England, the belemnites are confined to the lias, oolite, and chalk; there are nearly 30 British species. Near Charmouth, two strata of marl on the shore are literally paved with belemnites. From the fact that many belemnites have Serpulæ and other extraneous shells attached to them, it is justly inferred that the ink-bags and other soft parts had decomposed, and the guards lay long uncovered at the bottom of the sea.

The long celebrated Argonaut or paper nautilus has been at length restored to its true position as a genuine Cephalopod, belonging to the Octopoda, or those having eight feet or arms. This delicate shell is secreted between thin membranes expanded from one pair of the feet, and by them is enveloped during life, but without any muscular attachment; the shell therefore is readily detached by decomposition after death: "hence the doubts so long entertained as to the relation between the animal of the argonaut and its shell, but which are now set at rest."

It was formerly supposed that the sepia repeatedly found in the shell was an intruder, but it now appears that it was at home.† In the nautilus, when adult, there are about 35 septa or divisions, with as many chambers, whereas in the Argonaut there are none.

* Buckland, p. 377.

† I have seen this Cephalopod in the shell in the Marine Museum in Salem, in Boston, and another in a shop in Boston.—Sen. Ed.

In the British strata there are about 60 species of *Nautili.* The Nautili often form the nucleus of the clay nodules called *septaria.*

The *Orthoceræ* sometimes contain more than 60 cells, and they have been observed in Scotland 7 to 8 feet long.

Ammonites were formerly called *snake-stones;* swarms of snakes having been, as the legends report, turned into stone by the prayers of some patron saint. It is supposed that the animal of the Ammonite, like that of the modern nautilus, occupied the outer cell or chamber, which, although narrow, was long enough to contain the soft parts of the Cephalopod.

There are about 200* species of Ammonites in the British strata, varying in size from half an inch to four feet in diameter, the latter implying of course a colossal animal.

Among the Annelidæ, or worms, six fossil species have been observed in Britain in the Silurian system.

Of British Serpulæ there are fifty.

Crustaceans have been found through the vast series of the fossiliferous strata. Extinct forms appear, in prodigious numbers, in the most ancient formations, and are succeeded by genera which approach more nearly to the higher organized crustaceans. The crab and lobster tribes are represented by certain species in the lias, oolite, and chalk; while in many of the tertiary strata the existing types prevail.

More than 60 species of crustaceans were discovered by Count Munster in the Jura limestone, and more than 30 have been found in the Isle of Sheppey in the Thames. "The laminated marls of Auvergne in France contain, between the contiguous layers, countless myriads of the shells of Cyprides, through a depth of several hundred feet, although each lamina of marl scarcely exceeds the thickness of paper."

The trilobites are not found above the coal, but abound in the Silurian, while these older formations, through their immense thickness, contain no crabs, lobsters, or similar crustaceans.

Fossil Insects rarely occur except in a few localities at Œningen, Germany, and at Aix in Provençe, France, and in the cream-colored limestone of Solenhofen. Dr. Buckland has given an excellent account of fossil insects in his Bridgewater Treatise.

* The entire number known is at least 300.—Eds.

A *Buprestis* from Japan, an inch long, was found converted into *chalcedony*, with the antennæ and portions of the legs finely preserved, and the surface of the insect was covered with clusters of minute concentric rings of chalcedony.

Of Fishes, those now living exceed 8,000, and those in the fossil state, as ascertained by Agassiz, exceed 1,500; and several hundreds more remain undescribed.

Agassiz has classified the fishes by their scales, which are the most enduring part of their structure, and are the immediate means of connection with the external world, like the hair in quadrupeds and the feathers in birds. Characters of fishes are derived also from their bones, their teeth, and their tails, which are a prolongation of the vertebral column. In most modern fishes, the tail is rounded or divided into two equal lobes. In some, as the shark and dog-fish, the upper lobe is prolonged like a rudder, and the lower lobe is comparatively small and feeble. While this unequal tail is rare among existing fishes, it is found in all the fossil species that occur in the ancient secondary. The rounded and equal lobed tail prevails in all the fishes from the chalk upward, and the unequal lobed in all the fishes from the carboniferous era, (and downward?)

The greater part of the fishes of the secondary formations belong to the family of sharks; and the large rays or spines that are found belonged to them, having served the double purpose of defence, and as a support to the more delicate structure of the fins—as a mast which is movable for the adjustment of the sails. Immense numbers of teeth are found, especially of sharks; for the teeth being enamelled bone, they endure, while the cartilaginous framework of the shark has perished. The teeth are sometimes of enormous size—from Malta and the United States six inches long and five wide at the base, indicating sharks of twice the size or more of the largest living species, (the white shark,) which is sometimes forty feet long and upwards. A gigantic torpedo was discovered in Monte Bolca, and a perfect ray in Mount Lebanon, from which locality the editors of this Journal have received slabs of dun-colored limestone, containing schools of little fishes.*

* By the kindness of the Rev. Eli Smith, American missionary at Beyrût.

The most singular fishes that have been discovered were brought to light by Mr. Hugh Miller, in the old red sandstone of Caithness in Scotland; but to obtain an adequate idea of them, one must study his delightful work, "New Walks in an Old Field," one of the most eloquent, beautiful, and philosophical productions of science,—and its author began his career as a common quarryman.

Some of the more ancient fishes had teeth like the Saurians, and were occasionally of enormous size. All the species of fossil fishes are extinct;* but those of the tertiary approximate very nearly to those of our own time. The fishes are excellent geological indices; having such perfect organs of locomotion, they spread far and wide horizontally, but do not mix vertically—the same species not being common to different strata.

We have hardly glanced at the fishes, and the Reptiles we can do little more than to mention. Besides the *Saurians*, there are other reptiles:—the *Chelonians*, or Tortoises; the *Ophidians*, or Serpents; and the *Batrachians*, or Frogs.

In the language of Cuvier, "we revert to a different age of the world—to that epoch when the earth was occupied by cold blooded reptiles; when the sea abounded with Ammonites, Belemnites, Terebratulæ, Encrinites; and when all these races, now so extremely rare, formed the chief population of the globe."

The reptiles of the lizard family were denizens of the land, and the sea, and the air; they were herbivorous and carnivorous, and among them were creatures terrible in their forms, and colossal in size, and all of them such as the world now no where presents, for they are all extinct; although their analogues are found, being of a similar construction and destination. Their epoch was between the coal and the tertiary; none of the ancient Saurians survived the latter period.

The Ichthyosaurus had eyes of great size, and they were so constructed as to answer both for telescopic and for microscopic vision; they could, like turtles, lizards, and many birds, as for example the owl and the eagle, so vary the focus of the eye, as to see objects both near and distant. Sometimes the teeth amounted to 200, the vertebræ to 140, and the bones in some of their paddles to nearly 100. The swan has 24 vertebræ in its neck—

* Possibly a single exception in Iceland.

the greatest number among birds; while the Plesiosaurus has from 20 to 40.

Sixteen species of Plesiosauri and ten of Ichthyosauri have been described by Prof. Owen in the British strata alone. The Megalosaurus was about 30 feet long, probably terrestrial, and certainly carnivorous. The Hylæosaurus was from 20 to 30 feet long. The Iguanodon is now supposed not to have been more than 30 feet in length—less than one half of the length heretofore assigned to this animal; the tail was probably short, instead of being long like that of the Iguana, as had been supposed; and it is chiefly by shortening the tail that the reduction in length has been made. The colossal trunk admits of no diminution, and remains in all its gigantic proportions. The Mosasaurus is supposed to have been marine, and to have been about 25 feet long, with a tail serving him like an oar.

A fossil *land tortoise* has been discovered in India whose bones indicate a length of 12 to 14 feet, and a corresponding breadth. Bones of *serpents* that must have been 20 feet long have been discovered in the London clay, and the huge Batrachian or frog of Prof. Owen is supposed to have been of the size of a bull, or even of an elephant; it has been hitherto called the Chirotherium—from the hand-like impressions made by its feet, and by Mr. Owen, Labyrinthodon, from the convoluted internal structure of the teeth.

Fossil Birds have been found in considerable numbers in the tertiary, especially of the Paris basin; an albatross has been found in the chalk; and Dr. Mantell has discovered the bones of a heron even below the chalk in some of the deposits of the Wealden; nor was it believed that birds had existed at an earlier period.

But it is now fully admitted that birds, some of them of stupendous magnitude, once impressed the then soft and yielding materials of what is now the new red sandstone of the Connecticut River valley; the impressions made by their feet are exceedingly numerous—often sharp and well defined, and sometimes several consecutive tracks of the same bird occur, and are crossed occasionally by the tracks of other birds; among the very considerable number of species, some were small like the snipes and little waders of our beaches; others strode with a reach surpassing the power of a large man to equal the length of step, leaving cavities

more than twice the size of those of the largest ostrich, and capable of containing in them several quarts of water; there are also tracks of many intermediate dimensions. No bones having been certainly identified as belonging to these birds, the geological world were slow to believe; but Dr. Buckland, from the first, admitted the facts, and decisive specimens of the impressed tracks afterwards produced conviction in Dr. Mantell and his illustrious associates of the Geological Society of London; even Mr. Owen (whom peculiarly it became to be cautious, as he is now the Cuvier of comparative anatomy) gave in to the genuineness of the discovery, especially as the opportune arrival from New Zealand of the huge bones of the Dinornis proved that gigantic birds had existed at a comparatively modern geological epoch—even as late as the drift, and very possibly in the human era,—birds, some of which were fully as large as the largest described by Prof. Hitchcock is supposed to have been. We must wait with patience for the discovery of the bones of the fossil birds in the valley of the Connecticut—a discovery which we very confidently expect, as the tracks are very numerous, and the hydraulic and railway constructions and excavations are every day opening the quarries more and more. A large slab full of very perfect impressions of the feet of these birds has been furnished to the British Museum by Dr. James Deane, who very recently, with his associate Mr. Marsh, has disentombed specimens still more extraordinary, which are described in the present number of this Journal, as are also specimens equally gigantic by Prof. Hitchcock. The latter gentleman gave an account of quadrupedal tracks in the same rock to the Geological Association in 1842, and Dr. Deane has done the same in this number of this Journal; while Dr. Dana has, by chemical analysis, verified the genuineness of the coprolites discovered some time ago by Prof. Hithcock, and believed to have belonged to these birds.*

* Their respective claims to the merit of original discovery in this department of science have been recently presented to the public by Prof. Hitchcock and Dr. Deane, in the forty seventh volume of this Journal. To Prof. Hitchcock is due the signal and incontestable merit, not only of pursuing these researches through a series of years, during the first five of which, from 1835 to 1840, he labored alone, and discovered nearly thirty species, which were figured and described in his Final Geological Report upon Massachusetts, but he has the still higher merit of *establishing the philosophy of this subject.* He is the distinguished expounder of this department of geology, in the rock formation to which it appertains; and his name must

The classification of the Mammalia is—

I. Cetaceous, or animals of the *whale tribes.*

II. Ruminants; including the *giraffe, deer, oxen,* &c.

III. Pachydermata; including the *Proboscideans,* as the elephant; the ordinary *Pachyderms,* as the rhinoceros; and the *Solipeds,* or horses.

IV. Edentata; animals without teeth, or with only molar teeth, as the *sloth, ant-eater, Megatherium,* &c.

V. Rodents or Gnawers; as the *hare, beaver,* &c.

VI. Marsupialia; animals whose females have an abdominal pouch, as the *kangaroo.*

VII. Carnivora; including the *bats,* and the carnivorous tribes in general.

VIII. Quadrumana; *apes* and *monkeys.*

Many cetaceans have been discovered in elevated sea-beaches, proving the great changes of level in land and sea, even in very modern geological epochs. On the banks of the Forth the skeleton of a whale 72 feet long was found imbedded in clay. The Zeuglodon of Dr. Harlan, more than 70 feet long, was found in

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ever be honorably associated with fossil ornithology of the earliest epoch. Still, it is also true, that Dr. Deane, struck with the marked character of the fossil impressions that were presented to his observation, gave the earliest decided impulse towards these researches, by communicating specimens, descriptions, and casts, first to Prof. Hitchcock, and afterwards to the writer of these remarks in 1835, when he received a plaster cast of one of the ornithichnite impressions from Dr. Deane, accompanied by a distinct expression of the opinion that they were the genuine impressions of the feet of birds,—an opinion, however, which had been incidentally advanced by others at an earlier date. Dr. Deane has also followed up the subject since 1840, by frequent and successful researches in the quarries, and by freely communicating his specimens—first to his two geological friends, and two years since, to Dr. Mantell. Prof. Hitchcock had, *long before,* liberally distributed specimens both at home and abroad.

In the address delivered before the American Geological Association at Boston, in May, 1842, in adverting to the history of the Ornithichnites of the valley of the Connecticut, as a fact in strict chronological order, Dr. Deane was named first, and Prof. Hitchcock next. Not the remotest idea was entertained of placing the merits of Prof. Hitchcock on this subject in a second position. No one has delighted more to honor this distinguished geologist and excellent man, the early pupil and constant friend of the writer, who has on many occasions presented his just claims to high consideration, before both popular and academic audiences, and who was the first to espouse and zealously to defend his views on this subject; nor is it at all believed that he will fail, in the present instance, to occupy the eminent place which he now holds among men of science both at home and abroad. There is room enough in the world for all honest laborers in the great work of enlarging the boundaries of knowledge.

Alabama imbedded in tertiary limestone, and more recently a very perfect skeleton imbedded in clay.

The fossil oxen appear to have been one third larger than the modern; the horns were more massive, and one of them measured over 4 feet across at the widest expansion. The fossil elk of Iceland was 6 feet high, 9 feet long, 9½ to the top of the horn, and the space between the antlers was in some cases 12 feet. Fossil bones of the *giraffe* have been found in France, the camel and giraffe in the Sivalick mountains in India.

The author remarks, somewhat to our surprise, "that the mastodon and elephant can scarcely be regarded as generically distinct; for the dental organs present every modification of structure, from that of the mastoid tubercles of the tooth of the mastodon, to the vertical laminæ of cement, enamel, and dentine of the elephant." The gigantic mastodon of Mr. Koch, (his Missourium,) now in the British Museum, proves, as is stated by Dr. Mantell, that all the bones and teeth, apparently of several species, and as some have supposed of distinct genera, belong but to one grand mastodon.

The Dinotherium, the largest of terrestrial quadrupeds, was 18 feet long; this animal had a proboscis, and two tusks curved downward in the lower jaw.

The Paleotheria, the Megatherium, the Marsupials, the larger Carnivora, the bone caverns, &c. are too familiar to require a notice in this rapid abstract.

The *fossil Quadrumana* or *monkeys*, appear to have been the prelude to man. The ape has been found fossil in France, in the Himalayas, in the Brazils, and in England.

A gigantic quadrumanous animal appears to have walked the groves of India at the period of the early tertiary—a cotemporary with the colossal tortoise, Sivatherium and mastodon of the plains, and the Hippopotami of the marshes and rivers.

The fossil monkey of South America was four feet high.

Of the author's very interesting and instructive geological excursions in his own country we cannot give any abstract, and indeed they hardly admit of abridgment. His regular work he terminates with the following beautiful and impressive remarks.

"Ascending from the *granite*, that shroud which conceals forever from human ken the earliest remains of the earth's physical drama, the first glimpses we obtain of animated nature are a

few sea-weeds, and shells and crustacea. But can we doubt for a moment that that ancient sea had its boundaries and its shores? that then, as now, there were islands, and shores, and continents, and hills, and valleys, and streams, and rivers, teeming with appropriate inhabitants? The single drifted dicotyledonous leaf, in the carboniferous sea, affords as certain indications of dry land, as the olive branch which the dove brought back to the ark; one fact of this kind overthrows a host of theories based upon negative evidence.

"Advancing upwards, organic life presents more numerous modifications, but no traces of the highest orders of the animal kingdom are apparent, until on the sands of the ancient Triassic ocean we behold appearances as unexpected and startling as the human footstep to Crusoe on his desolate island—the tracks of biped colossal birds, of which no other vestiges remain, and to which the existing order of creation affords no parallel.

"We now enter upon that marvellous epoch during which reptilian organization obtained its full development—when the Iguanodon and Megalosaurus,

> 'Mighty pre-Adamites, who walk'd on the earth
> Of which ours is the wreck,'*

were the inhabitants of vast islands and continents. But here, as in earlier periods, we have proof that warm-blooded animals existed, and the diminutive marsupial and insectivorous mammalia of the oolite, the heron of the Wealden, and the albatross of the chalk, attest that the system of animal creation was complete.

"Leaving behind the age of reptiles, we approach that of the colossal mammalia, when extensive countries were peopled by the enormous herbivorous Megatheria, the mastodons, and other gigantic Pachydermata, long since become extinct. But with these last races many existing species were cotemporary, including the monkey tribes, which, of all animals, approach nearest to man in their physical organization. Thus by slow and almost imperceptible gradations, we arrive at the present state of animate and inanimate nature. But even after the existing continents had attained their present configuration in the period immediately antecedent to the human epoch, innumerable tribes of carnivorous animals swarmed throughout the temperate climates

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* Byron.

of Europe: the tiger lurked in the jungle; the lion slept in his lair; the hyena prowled through the woods; the bear inhabited the caverns; and gigantic elks, oxen, horses, and deer, tenanted the plains. But of man and his works not a vestige appears throughout the vast periods embraced in this review. Yet, were any of the existing islands or continents to be engulphed in the depths of the ocean, and loaded with marine detritus, and in future ages to be elevated above the waters, covered with consolidated mud and sand, how different would be the characters of those strata from any which have preceded them! Their most striking features would be the remains of man, and the productions of human art—the domes of his temples, the columns of his palaces, the arches of his stupendous bridges of iron and stone, the ruins of his towns and cities, and the durable remnants of his earthly tenement imbedded in the rocks and strata—these would be the 'Medals of Creation' of the *human epoch*, and transmit to the remotest periods of time a faithful record of the present condition of the surface of the earth and of its inhabitants."*

After so grave a march through creation, we may be allowed to introduce a few miscellaneous things before we close.

The dedication to the author's friend, Mr. Lyell, is a warm-hearted tribute of respect and regard to a distinguished man who has rendered great service to the cause. The opening of the address to the courteous reader, "and still more courteous purchaser," furnishes an important practical hint not always remembered by the *admiring* and *non-buying* world.

The author has not forgotten to thank his "excellent printer," and also his compositors, "for their skill and patience in deciphering hieroglyphics, at all times somewhat illegible, and rendered peculiarly so on the present occasion, from the greater part of the manuscript having been written under the pressure of severe bodily suffering. I may say," remarks the author, "with *Gerald Griffin*, that 'I verily believe, if I shut my eyes, or flung my pen at the paper, so as to make a mark of any kind, my printers would find out what I meant. They always send me back my manuscript with the printed proofs for correction; and I actually have repeatedly been unable to make out what I had written, until I referred to the same sentence in print.'" Not a

* See Sir H. Davy's Last Days of a Philosopher.

few authors and compositors would find the above an exact description of their own case.

An excellent summary is given of M. Adolphe Brongniart's discoveries in fossil botany, and it is compressed into only three pages. There is an interesting notice of the Flora of New Zealand, p. 202. The chapter on fossil infusoria is important. The article on fossil zoophytes is very valuable; being condensed from a vast store of materials, it must have been very laborious, and it is illustrated by beautiful drawings, particularly on page 279. An excellent account is given of the Cephalopods, and of the fossil fishes, especially of Agassiz, both requiring great labor and skillful condensation; but the effort has resulted in a lucid exhibition of both these great departments.

Thus, chiefly by making our author his own interpreter, we have endeavored to present a full and intelligible view of his design. Our object has been to give a faithful analysis of an important and interesting work. In the execution, Dr. Mantell has embodied a vast amount of results drawn from numerous resources of the highest authority; it is evidently a work of great research and formidable labor, for which any one may well be very thankful who desires to know, or both to know and to communicate, the great facts and beautiful philosophy of paleontology. *This work is a classic of high excellence*, and must necessarily be the companion of every geologist who is not willing or has not the time or the means to study it out for himself, from a wide range of research to which few are equal.

In this cursory review, and within the limits of this Journal, it is impossible to quote even a moderate proportion of the excellent cases selected by the author to illustrate the organic beings now entombed in the earth. Although these pages have been extended far beyond our original design, we have found it possible to select only a few bright remarks and striking facts, sufficient to induce the reader to purchase and study the work for himself.

We cannot however close our observations without again expressing our admiration of the perspicuity, method, and condensation by which these volumes are distinguished. They are in relation to the whole of paleontology what Professor Buckland's incomparable Bridgewater Treatise is, for the splendid examples which he had so happily selected, and so ably described and illustrated.

Dr. Mantell has written his work under the pressure of severe infirmity, and it is a noble example of the superiority of the mind to the sufferings of the body. If there is less of flowing and captivating eloquence in the "Medals of Creation" than in the "Wonders of Geology," it is because the plan requires the most rigid accuracy, and the utmost technical precision; still we find in his introductions and retrospects the same captivating diction, and the same lucid philosophy, which have delighted the readers of the Wonders, and the four uniform volumes may well go forth in company, as they form a harmonious unity, replete with instruction and entertainment.

SENIOR EDITOR.

November 27, 1844.

ART. XII.—*New Experiments on the Solar Spectrum;* communicated by Professor OLMSTED.

SOME months since I was invited by my friend, Mr. Forrest Shepherd, of this city, to witness some experiments which he had devised on colors. I was not only much delighted with the singularly beautiful and diversified figures and colors which he produced from the solar spectrum, but also surprised by their novelty, since I had never either heard or read of any similar experiments.

Mr. Shepherd had been led to make some researches upon colors in consequence of having witnessed, in the year 1826, upon a peak of the White Mountains, that beautiful phenomenon called the "apotheosis of travellers," in which the shadow of the spectator, thrown by the sun on a stratum of clouds below him, is seen with the head encircled by a splendid coronet of rainbows.* This gorgeous spectacle has been enjoyed and described by a few other travellers who have ascended high mountains, as Bouguer, Saussure, and especially by Ramond, who saw it in great perfection on the summit of the Pic Du Midi.†

With the view of repeating and varying Mr. Shepherd's experiments, I availed myself of a small dark chamber fitted up

* Amer. Journal of Science, Vol. XII, p. 172.

† London Quart. Jour. Science, Literature and Arts, 1827. Malte Brun's Geography, Vol. I.

for a camera obscura, having an eastern exposure, with a circular aperture in the window shutter three fourths of an inch in diameter. When the morning sun is shining bright, say from eight to ten o'clock, I place a glass prism in the beam that enters this opening, and form the prismatic spectrum on the opposite wall, distant ten feet. The direct solar beam affords a brighter spectrum than when introduced by a mirror, as in the heliostat; and the distance of ten feet is found to afford a spectrum of convenient dimensions for the subsequent experiments.

It is now only necessary to introduce into the prismatic beam, between the prism and the wall, any reflecting or refracting medium, or both combined, and we are surprised with the appearance on the wall, around the spectrum, of an endless variety of figures, for the most part perfectly symmetrical, and exhibiting hues more gorgeous than I have ever seen developed by any other means, either in art or nature. Since every change in the reflecting or refracting medium produces a new variety of figures, and a new combination of colors, the exhibition may be endlessly varied. I will subjoin a few examples, which will be understood to be merely a few terms of an infinite series.

First, a *glass tube* an inch in diameter* is held in the prismatic beam in the direction of the plane of the rays. Immediately, the several prismatic colors arrange themselves on the wall in broad circular zones. The circles will be larger as the tube is held farther from the wall; and, at a given distance, the dimensions of the figures may be varied by changing the inclination of the tube, being small when the tube approaches a horizontal direction, and enlarging as the tube is raised towards a perpendicular position, until they encompass the entire room. Inequalities in the glass serve to diversify each individual zone, still preserving, as in the kaleidoscope, remarkable symmetry of arrangement. Thus, we not unfrequently observe the zones chequered by a gossamer net-work. If the prismatic beam is suffered to fall obliquely on the end of the tube, so that a part of the light falls upon the convex and a part upon the concave surface, peculiarly agreeable diversities of colors are developed; and if the tube is bent into the form of a syphon, the two arms pre-

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* A tube of *any* diameter will show the effect, in a greater or less degree—a common Argand lamp chimney will answer the purpose.

sent each a set of rings, pleasingly combined with each other, and the bend may be made to afford various figures still more remarkable.

Secondly, a glass *retort*, by its diversity of figure, affords a convenient means of developing new combinations of forms and colors. When the vessel is half full of pure water—when drops of water stand around the neck of the retort—when bubbles, as soap-bubbles, fill the upper part of the vessel—and finally, when different kinds of transparent fluids are iutroduced into the retort, corresponding changes of figures and colors start into existence, too singular and striking to admit of adequate description. Indeed, it seems hardly necessary to describe appearances, which every one can so easily produce for himself.

Thirdly, a *wine-glass* or *beer-glass*, (of a recurved figure, flaring at top,) half full of water, is placed on a stand, and portions of it are successively elevated into the prismatic beam. When the light strikes upon the reflecting and refracting surfaces of the upper rim—when it passes through the body of the vessel below—when it meets with the tremulous surface of the water—when it enters the latter—and, finally, when it meets the various curvatures that form the pedestal of the vessel—in each case, we are presented with images and combinations of color truly novel and admirable.

Fourthly, *double media* frequently afford fine images. Thus, if we let the prismatic beam first pass through the upper part of the wine-glass, and then strike on the glass tube, circular zones of many blended hues are developed.

Fifthly, highly polished metallic *reflectors*, of curvilinear figures, give reflected images of curious shades and shapes. A cream-cup, of platina ware, having a surface variously curved, reflects an image not unlike an expanded peacock's tail, but far more brilliant; and a small convex mirror, gives a semi-ellipsis, studded with gems, well representing a pontifical mitre. A boy's cap of shining India rubber affords a pleasing variety of reflected images.

The foregoing are only a few of the splendid pictures which I have at different times formed by this method. Indeed, since, as already observed, the least change in either the reflecting or the refracting medium, develops new images, varying in form and color, this new field of experiment seems absolutely unlimited.

One derives from these exhibitions new ideas respecting the riches of the solar beam, and new impressions of the boundless resources which nature has in this beam for adorning and diversifying her works. Nor does this class of experiments seem unworthy the attention and study of the painter, who may find here combinations of colors far richer and more superb than any which his pencil can paint. Finally, the philosopher and the mathematician will find ample scope for their powers, in developing the laws which govern these endless varieties of figure and color.

Art. XIII.—*Caricography;* by Prof. C. Dewey.

(Appendix, continued from Vol. XLIII, p. 92.)

No. 177. Carex *Mitchelliana*, Curtis. Tab. Dd, fig. 98.

Spicis binis vel ternis *distigmaticis* cylindraceis subremotis oblongis subdensifloris pedunculatis, superiore androgyna inferne staminifera, inferioribus pistilliferis brevi-vaginatis suberectis; fructibus ovatis acutis brevi-rostratis glabris ore indiviso, squama ovato-cuspidata paulo brevioribus vel subæquantibus.

Culm 15–20 inches high, erect, acutely 3-sided, subscabrous above, leafy towards the base; leaves linear-lanceolate, flat, nerved, smooth, shorter than the culm; spikes 2–3, pedicellate, an inch long, cylindric, not densely flowered, the upper one staminate below, and sometimes above also, the lower with a long leafy bract scarcely sheathing the peduncle; staminate scale oblong lanceolate; stigmas two; fruit ovate, acutish, short-beaked, somewhat convex, with a scale ovate or oblong-cuspidate, and about as long or longer than the fruit.

Resembles C. *gynandra*, Schw., and belongs in the section with C. *crinita;* flowers in May. Discovered by Rev. Moses A. Curtis, in wet places in Chatham County, N. C. in 1835, and first described by him in this Journal, Vol. XLIV, p. 84.

The following variety of another species was also described by Mr. Curtis on the same page.

C. *verrucosa*, Muh. C. *glaucescens*, Ell. var. *androgyna*, Curtis. Tab. Dd, fig. 99.

Spicis longo-cylindraceis densifloris (4–7) erectis tristigmaticis, superiore androgyna inferne staminifera; culmo 3–4 pedali longo-foliaceis bracteisque, omnino glaucis.

Culm 3–4 feet high, with large leaves overtopping it; whole plant glaucous; flowers in October, and is considered by Mr. Curtis as an autumnal variety; and to his opinion every botanist will respond, that it is a most splendid species.

The C. *glaucescens*, Ell. and C. *verrucosa*, Ell. appear to be only varieties of C. *verrucosa*, Muh., and the preceding variety belongs therefore to the species named by Muhlenberg. The C. *verrucosa*, Muh. is there a very variable plant, flowering at different seasons, and showing sometimes several staminate spikes, sometimes only one, and sometimes an androgynous spike. The description of C. *glaucescens*, Ell. is in Vol. XI, p. 150, Tab. M, fig. 39.

No. 178. C. *miser*, Buckley. Tab. Dd, fig. 100.

Spicis distinctis; staminifera unica ebracteata, squamaque oblonga obtusa margine membranacea; pistilliferis binis vel ternis *tristigmaticis* pedunculatis subapproximatis erectis laxifloris bracteatis; fructibus lanceolatis subtriquetris glabris, squama ovata obtusa duplo longioribus.

Culm 8–12 inches high, erect, 3-sided, leafy towards the base, and with long leafy bracts scarcely sheathing the peduncles; leaves many, short, narrow, smooth; staminate spike single, half an inch long, loose-flowered, dark brown, with oblong and obtuse scales membranaceous at the margin; pistillate spikes 2–3, on filiform peduncles about half an inch long, loose-fruited; fruit lanceolate, smooth, twice as long as the ovate and obtusish scales, membranaceous on the margin; plant slender, and of a *poor aspect*, as its name implies.

Found by S. B. Buckley on Roan Mountain in North Carolina, and first described by him with the two following species in this Journal, Vol. XLV, p. 173. Related to C. *tetanica*, Schk., but is very remote from it.

No. 179. C. *styloflexa*, Buckley. Tab. Dd, fig. 101.

Spicis distinctis; staminifera solitaria brevi vel longo-pedunculata; pistilliferis (2–4) subternis *tristigmaticis* ovatis vel oblongis subsparsifloris, superiore subsessili erecta, inferioribus longo-exserte pedunculatis retrocurvis folioso-bracteatis; fructibus ovatis triquetris acutis vix inflatis curvo-rostratis bidentatis, squama oblonga mucronata margine membranacea paulo longioribus.

Culm two feet high, rather slender, 3-sided, leafy at the base; leaves linear, flat, nerved, smooth, much shorter than the culm; staminate spike about an inch long, cylindric, sometimes very long-pedunculate, with oblong-linear acute scales; pistillate spikes 2–4, oblong and loose-flowered, upper one short-pedunculate or sessile with a short and scarcely sheathing bract, the lower often very long pedunculate and recurved with short sheaths and long leafy bracts; stigmas three; fruit ovate, 3-sided, somewhat stiped, recurved-rostrate, 2-toothed and nerved; pistillate scale ovate, oblong, acute or mucronate, membranaceous on the margin, and usually a little shorter than the fruit.

Found on the mountains of Macon County, N. C. by S. B. Buckley; resembles C. *anceps*, Muh., but is far different.

No. 180. C. *Caroliniana*, Buckley. Tab. Dd, fig. 102.

Spicis distinctis; staminifera unica squamaceo-bracteata; pistilliferis binis vel ternis *tristigmaticis* longo-exserte pedunculatis perdistantibus paucifloris, inferiore subradicali; fructibus (3–6) ovatis brevi-conicis subtriquetris alternis, squamam ovatum acutam subæquantibus.

Culms 8–16 inches high, slender, striate, leafy at the base, in tufts with numerous flat and nerved radical leaves which are sometimes half an inch wide, and often equal to the culm in length; bracts narrow and leafy, partly sheathing the filiform peduncles; staminate spike half an inch long, with a scaly and acute bract at the base, and with obtuse oblong and reddish brown close scales; pistillate spikes (2–3) on long peduncles, few-fruited; stigmas three; fruit ovate, 3-sided, alternate, with a conic termination, and about equal to the ovate acute scale. Culms of very different length on the same tuft; flowers from April to May.

Found on Table Mountain, S. C. by S. B. Buckley; has a very *depauperate* appearance, but is very remote from C. *depauperata*, Good.

No. 181. C. *triceps*, Mx. C. *triceps?* Ell. Tab. Dd, fig. 103.

Spicis *tristigmaticis* ternis brevi-ovatis erectis approximatis sessilibus, superiore androgyna brevi-pedunculata inferne staminifera, inferiore folioso-bracteata; fructibus triquetro-ovatis obtusis glabris, squama ovata acuta subduplo longioribus.

Culm about a foot high, 3-sided, glabrous; leaves subradical, linear, smooth, striate, shorter than the culm; spikes three, upper one staminate below, short-pedunculate; two lower spikes ovate, sessile, short, close-fruited, and the lowest with a long leafy bract; stigmas three; fruit ovate, 3-sided, obtuse, and longer than the ovate and acute scale; whole plant pale green.

Found in North Carolina by Rev. M. A. Curtis, and is undoubtedly the true plant of Michaux, as he gives the same locality, though it has been thought to be a variety of C. *hirsuta*, Willd. But this last is a *hirsute* plant, with much larger spikes and a pistillate scale *equalling* the fruit. There can be no doubt that Michaux would have mentioned the hirsute leaves and culm if they belonged to C. *triceps*. It is now evident that C. *virescens*, Muh., C. *hirsuta*, Willd., and C. *triceps*, Mx., correspond to the description of their authors, and this series is now complete.

No. 182. C. *Buckleyi*, Dewey. C. *Gebhardii*, Buckl. non Schk.
Tab. Dd, fig. 104.

Spica composita, spiculis subquinis ovatis alternis approximatis sessilibus inferne staminiferis *bistigmaticis;* fructibus ovato-lanceolatis ore bilobo, squama ovata acuta subduplo longioribus.

Culm slender, erect, 3-sided, more than a foot high, with linear-lanceolate leaves towards the base; spikelets about five, ovate, sessile, rather near, alternate; stamens chiefly at the base of the upper spikelet, with oblong and obtuse scales; stigmas two; fruit ovate-lanceolate, somewhat concave or flat below, smooth, with a short two-lobed orifice, and with ovate and acute scales.

Found in the mountains of Carolina and Georgia by S. B. Buckley, and named C. *Gebhardii*, Schk., to which, as well as to C. *scirpoides*, it is related. From the latter it is separated by several characters, and from the former in its spikes, fruit, &c. C. *Gebhardii* is a shorter, thicker and heavier plant, has about nine spikelets, and its fruit oblong, roundish, sharply acuminated into a short beak, with an ovate and abruptly acute or obtusish scale. The resemblance between our plant and the *figure* of C. *Gebhardii* in Schkur is much greater than between the two plants as we have compared it with specimens of C. *Gebhardii* from Germany. It has accordingly been named in honor of the discoverer, an active and successful botanist.

No. 183. C. *Cooleyi*, Dewey. Tab. Dd, fig. 105.

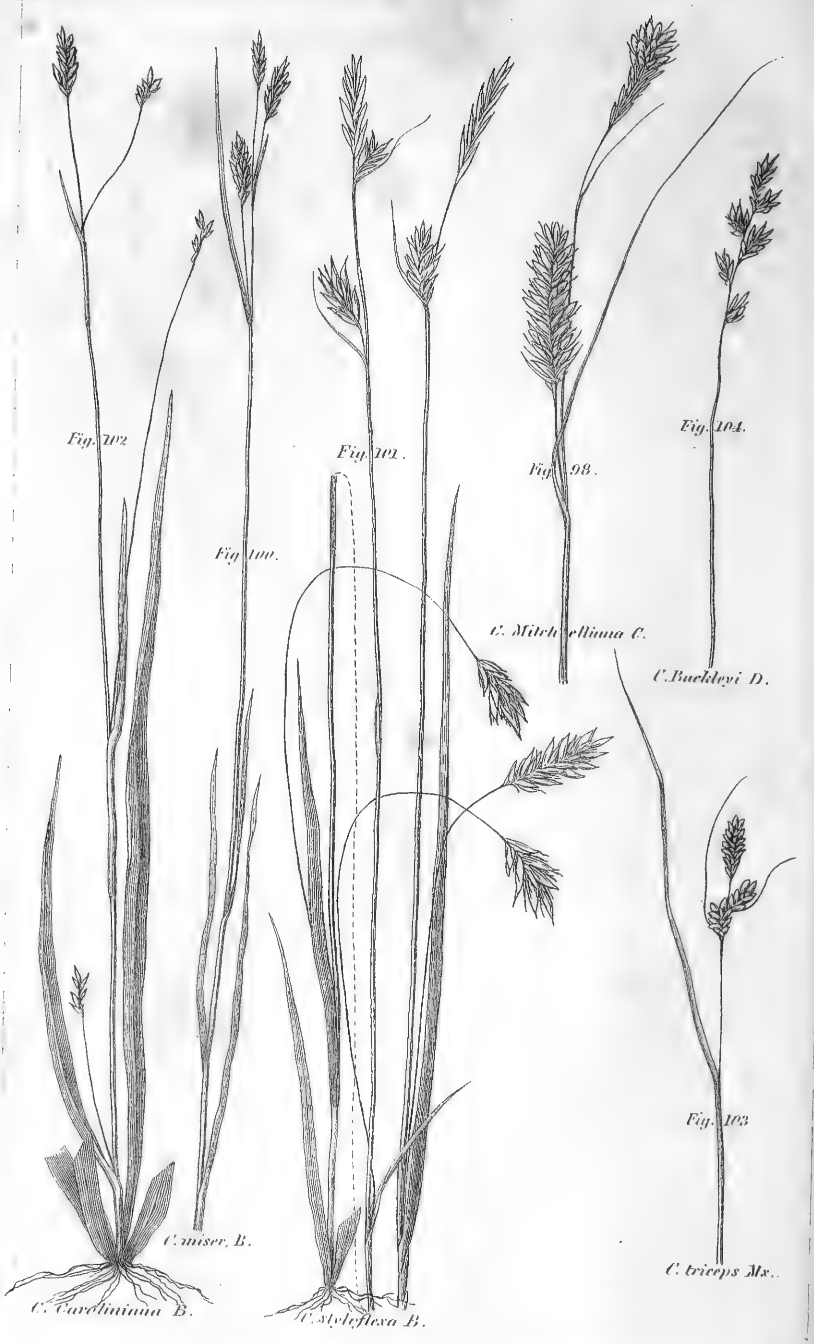
Spicis distinctis, staminifera solitaria parvo-cylindracea bracteata; pistilliferis *tristigmaticis* subternis (2–4) oblongis cylindraceis subdensifloris, superiore interdum subsessili, inferioribus vulgo longo-pedunculatis retrocurvis; fructibus ovatis conico-rostratis bifurcatis subinflatis nervo-costatis glabris, squamam ovatam cuspidatam scabram subæquantibus.

Culm 20–30 inches high, triquetrous, scabrous; bracts and leaves very long, surpassing the culm, linear-lanceolate, striate or nerved, glabrous, scabrous on the edge; staminate spike single, small, with an oblong-lanceolate scale; pistillate spikes 2–4, cylindric, oblong, upper sometimes short-pedunculate or subsessile, the lower long pedunculate, and the lowest often very long, and all on filiform peduncles recurved and partially sheathed; sometimes the upper pistillate is staminate above; stigmas three; fruit ovate lance-rostrate, two-toothed, strongly nerved and even costate in maturity, smooth and glabrous; pistillate scale ovate, cuspidate, as long or longer than the fruit.

Found in swamps by Dr. D. Cooley, at Washington, Macomb County, Michigan. It is related to C. *hystericina*, Willd., but is far different.

Figures of the following species accompany this paper.

No. 177.	C. *Mitchelliana*, Curtis,	Tab.	Dd,	fig.	98.
	C. *verrucosa*, Muh.				
	var. *androgyna*, C.	Tab.	Dd,	fig.	99.
No. 178.	C. *miser*, Buckley,	"	"	"	100.
No. 179.	C. *styloflexa*, Buckley,	"	"	"	101.
No. 180.	C. *Caroliniana*, Buckley,	"	"	"	102.
No. 181.	C. *triceps*, Mx.	"	"	"	103.
No. 182.	C. *Buckleyi*, D.	"	"	"	104.
No. 183.	C. *Cooleyi*, D.	"	"	"	105.



DEWEY'S CARICES,

Fig. 99.

C. verrucosa,
Var. androgyna C.

Fig. 105.
C. Cooleyi D.

TAB. D d.

Art. XIV.—(1.) *Remarks on the Alabama Meteoric Iron, with a Chemical Analysis of the drops of Green Liquid which exude from it;* by Charles T. Jackson, M. D. (2.) *Letter from* Mr. A. A. Hayes *on the same subject, with remarks on the origin of the Chlorine found in the Alabama Iron, and a description of new methods employed in the Analysis of Meteoric Irons.**

I. *Dr. Jackson's Remarks on the Alabama Meteoric Iron.*

In August, 1834, I made a chemical analysis of a piece of meteoric iron from Claiborne, Clarke County, Alabama, and published the results of that analysis in the thirty fourth volume of this Journal, in 1838. The discovery of chlorine, combined with nickel and iron, then announced for the first time, was a new fact in the science of meteorites, and was regarded as one of interest and importance. The attention of chemists was called to a re-examination of specimens, which are contained in the numerous cabinets of Europe and this country, in the belief that the presence of chlorine might have been overlooked in former analyses.

In 1839, Prof. C. U. Shepard announced to the British Association, that he had discovered chlorine in a specimen of meteoric iron from Buncombe, N. C., and as I understand, stated at that time, as he has done since in this Journal, that the presence of that element in meteorites, was first discovered by me, but that statement was accidentally omitted in printing the Reports of the British Association. I was gratified on seeing an account of Prof. Shepard's discovery, and regret that he has since been disposed to cast a doubt over the celestial origin of the chlorine, considering the facts which he has published in the forty third volume (p. 359) as in no way invalidating the opinion that chlorine was an original ingredient of the meteorite. No one who views my specimen can have any doubt on the subject, for chlorohydrates of nickel and iron are copiously effused from the interior of the mass, and from every point on the cut and polished surface, where the specimen had been sawed asunder, insomuch that I am unable, even in a close cabinet, to keep the specimen free from cor-

* Read before the Boston Society of Natural History, Wednesday, Nov. 20, 1844, by Dr. Jackson.

rosion. Drops of a grass green liquid, from the size of a pin's head to that of a pea, are constantly forming upon it, and run down upon the shelf of the cabinet, leaving a thin shell of the peroxide of iron in the place of the drops. With the utmost care, and by layers of varnish, I have not been able to retain its surface bright longer than a few days.

The natural exterior portion of the mass does not give out any drops of the chlorohydrates, for the chlorine has long since been exhausted therefrom; but its recently cut surface, which is at first apparently as sound and brilliant as pure malleable iron, gives out minute drops, and etches itself so as to show a crystalline structure, after a few hours' exposure to the air. It would be difficult to persuade any chemist that chlorine could penetrate through a crust of compact malleable iron, and reach the centre of a solid mass of the metal, and there combine intimately with the iron and nickel, forming with them a uniform alloy, if I may so call it; for the chlorine is combined with the metals in a dry state, and is only rendered apparent by its combination with the hydrogen of a moist atmosphere, while the metal is at the same time oxidated.

I have analyzed this liquid exudation, and obtained the following results.

On the clear green liquid washed from the specimen by water:

Chlorohydric acid, ...	0·8216
Oxide of nickel, ...	0·6000
Protoxide of iron, ...	1·7000
	3·1216

besides the water of solution.

N. B. No muriatic acid has ever been applied to this mass of meteoric iron, and the drops here described came from a recently cut surface.

11·7 grains of the exuded green drops, with the thin crusts of peroxide of iron scraped from the specimen, were dissolved in pure nitric acid and distilled water, and the chlorine was separated by a solution of nitrate of silver, as a chloride of silver, and this was dried, fused and weighed, and the quantity of chlorine calculated therefrom. The excess of silver being removed from the solution which remained, by chlorohydric acid, the peroxide of iron was precipitated after adding a large proportion of chloro-

hydrate of ammonia, by means of an excess of pure ammonia. Then after filtration, the blue nickeliferous solution was evaporated to dryness, and the excess of ammoniacal salts expelled, and the oxide of nickel redissolved in chlorohydric acid and water, was precipitated by pure potash, washed, ignited, and weighed.

The results of this analysis were as follows:

Chlorohydric acid, ...	1·6468
Protoxide of iron, ...	3·2318
Oxide of nickel, ...	2·0000
Water by difference, ...	4·8214
	11·7000

Since the completion of the above analyses, I presented Mr. A. A. Hayes of Roxbury with some slices sawed from the principal mass of the Alabama meteoric iron, and another piece, which had not been subjected to any chemical researches, with the request that he would submit them to a rigorous chemical examination. I also called his attention to Prof. Shepard's article in Vol. XLIII of this Journal, and requested his views, regarding the possibility of impregnation of metallic iron with chlorine by the action of any of the chlorides or chlorohydrates in sea water, or the soil. I also desired to know if chlorine ever penetrated the iron, which is exposed to it in the manufacture of chlorohydric acid. After long and patient researches, he has presented the following communication, which bears ample proofs of science and analytical skill. It is to be hoped that he will also communicate the results of his observations on the action of sea-water on kentledge iron. C. T. Jackson.

II. *Mr. Hayes's Letter.*

To Dr. Charles T. Jackson:

My dear Sir—The most suitable return I can make for your liberal kindness, in giving me some fine specimens of the Alabama meteorite, is an account of some experiments I have made, in an investigation of the composition of this substance.

You will perhaps consider the evidence I shall adduce, in connexion with the existence of chlorine, as a constituent of this extra-mundane body, as uncalled for; that fact having been long since established and made public by yourself in a manner which would seem to leave little room for doubt. On this point, after

witnessing your experiments, I had the same confident belief as yourself, and considered the fact when announced as an important addition to our knowledge; one that no subsequent researches would set aside. The discussion respecting the *origin* of the chlorine contained in this meteorite, which occurred at the meeting of the Geological Association in Boston, led me to conclude that a difference of opinion prevailed among scientific men on this subject. The subject was then ably treated, although some suppositions would have hardly been suggested had the chemical evidence contained in your memoir been duly considered.

More lately the Annual Report of Berzelius,* which from the accuracy and impartiality of his remarks has become a standard authority in chemical science, contains a notice of a paper, by Prof. Shepard,† in which the writer attempts to prove by experiment that the hydrochlorates of iron and nickel, exuding from the Alabama meteorite, is not due to the chlorine originally contained in the iron. Thus, what was ten years since established as a chemical fact, has even now become a subject for doubt. Those who have traced the progress of chemical discovery for some past years, must have observed the contradictory statements which have from time to time appeared in relation to the discovery and existence of chlorine in other specimens of meteorites. It is not therefore a matter of surprise that doubts should have been raised regarding the facts you had published. The paper of Prof. Shepard, from the notice taken of it by Berzelius, is supposed to contain all the grounds for diversity of belief which have been presented; it is not my intention to examine them here. I will remark, that the detection of chlorine in a mass of kentledge iron which had long been exposed to the action of sea-water, has not any direct bearing on the question of the existence of chlorides of iron and nickel in the Alabama meteorite. Of foreign kentledge, as it arrives here, one twentieth part exhibits the same fracture and structure as that of the mass described by Prof. S. It is a common result of cooling iron suddenly in moist sand. The action of the atmosphere, aided by the saline matters of sea-water, or highly crystalline

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* Report for 1843, French edition, p. 170.

† American Journal of Science, Vol. XLIII, p. 359.

cast-iron, results in the withdrawal of the amorphous or more slightly aggregated part, leaving the mass porous, and the laminæ disintegrated. This removal is not a consequence of the porosity of the mass, but a cause; observations made here show that porous granular cast-iron does *not* absorb chlorine, hydrochloric acid, or chloride of iron, after an exposure varying with the specimens in time, from nine months to ten years. Malleable iron, under the same circumstances of exposure, is also impermeable to these substances. When fragments of iron detached from masses which had become oxidized through more than one half the original thickness, by exposure in earth containing saline substances, were carefully tested for acids and bases, no traces were discovered.

The paper contains no answer to the first question which is suggested to the mind of a chemist—With what base is the chlorine or hydrochloric acid combined? The experiments seem to have reference to the detection of chlorine only; and from the account given of them, I infer that even the ordinary precaution of washing the masses, or otherwise removing the chlorides from obvious sources, was not taken. In the announcement of your discovery,* the simple experiments are given, demonstrating the existence of chlorides of iron and nickel. When it has been experimentally shown how chlorine, derived from the decomposition of any saline compounds, especially those with the bases of which it has stronger affinities, can pass into a mass of iron, alloyed with nickel, and unite with both metals, I shall return to this part of the subject with pleasure.

The following is an account of experiments made on different specimens of the Alabama meteorite.

An oval mass weighing about eight ounces, completely covered by a thick, brown coating of oxide of iron, from atmospheric exposure, had a portion of its surface filed bright. The bright surface was pressed in contact with the interior of a platina basin, and some dilute muriatic acid used to produce chemical action. The addition of the acid from time to time caused the reduction and solution of the investing coating, leaving a clean metallic surface; after washing the mass in warm pure water, it exhibited the appearance of inlaid work, produced by the arrangement

* American Journal of Science, Vol. xxxiv, p. 333.

of delicate brilliant folia; or was dotted by minute crystalline portions of pyrites. The color of the general surface was light gray. Under a lens the texture resembled that of ductile iron, containing innumerable glimmering points of unequal size. It could be polished but under the file, or with cutting instruments. It had the characters of cast-iron, and would not afford a shaving. There were a few dots of an earthy mineral or rock, having a magnesian base, closely adhering to fragments of pyrites. Cavities and extreme irregularity of surface denoted very unequal action of the atmosphere on different parts of the mass.

Warm pure water was used to remove every trace of soluble matter from the clear surface of the mass; and the last washings would not change the transparency of a solution of nitrate of silver. The bright surface, when dried, would rapidly oxidize if exposed to moist air. An exposure of a few hours would cause the appearance of brown spots, irregularly disposed; and soon after the surface would become studded with innumerable minute drops of a greenish white fluid which had apparently exuded from the mass. As these drops increased in size, they deposited an ochry precipitate, and would finally flow off, leaving the surface corroded. The fluid formed by collecting these drops, when mixed with a solution of nitrate of silver, caused the deposition of thick curdy matter, which, after being washed, would become purple colored in sunlight. Decomposed by metallic zinc in dilute sulphuric acid, the curdy matter afforded hydrochloric acid and silver; no trace of iodine or bromine existed. The fluid which had afforded the precipitate, with the nitrate of silver containing silver in solution, was boiled with muriatic and nitric acids; the clear fluid separated. On adding an excess of pure ammonia to the nitro-muriatic solution, a brown oxide of iron was precipitated, while a clear violet blue fluid remained above it. The blue fluid by evaporation afforded a dry mass, in which neither copper or cobalt could be detected. Besides ammonia salts, pure oxide of nickel only remained. The platina basin, in which the reduction of the oxide had been effected, contained a green solution above some angular brilliant grains of bisulphuret of iron. The solution containing the oxides dissolved from the mass of meteorite was divided; so much as contained above two hundred grains of oxides was exposed to a current of sulphydric acid for two hours; no precipitation or change of

color occurred. An excess of pure ammonia was added, the fluid warmed, and the current of gas continued until an excess was indicated. By warming the fluid the sulphurets precipitated, leaving a colorless solution above them. The fluid was evaporated, the ammoniacal salts dissipated by heat, left an earth-like matter weighing less than 0·10, which afforded indications of nickel, magnesia, chlorine, and soda; a very light siliceous matter remaining undissolved.

The sulphurets were oxidized by nitric acid, and the solution decomposed by ammonia in excess; the precipitate which a filter would separate was washed in boiling water. It was boiled in a solution of carbonate of soda to a dry mass, and after the addition of nitrate of soda exposed in a platina crucible to the heat of bright redness. The mass after it became cool was brown, portions of white fused salts appearing on parts of the surface. Aqueous solutions, obtained by cold or hot water, were free from vanadic, chromic, titanic, silicic, or phosphoric acid; nor could any traces of earths or oxides be discovered in the solutions. The washed residue had the characters of peroxide of iron. The ammoniacal fluid was evaporated, and caustic potash used to decompose ammoniacal salts. The dry mass afforded a colorless solution in water, having black oxide of nickel undissolved. The gas evolved by acting on fragments of the meteorite with diluted muriatic acid was odorless; when inflamed, the jet of gas was colorless; while burning it did not deposit any film when directed on the surface of cold water.

From these trials, I infer that the mass of the meteorite is made up of iron and nickel, and that the chlorine is united to iron and nickel; bisulphuret of iron and traces of earthy matter are also present. The compound of chlorine, iron, and nickel, has a *metalloidal character* not interfering with the production of a polished surface, but subject to rapid action in moist air. To learn how this compound is distributed throughout the metallic matter, I resorted to a method of testing which has been described to the Boston Chemical Society. The slip of meteorite which was selected for the experiments had been sawed from a central part of a large mass some months previously. It had been closely enwrapped in waxed paper, and with other slips prepared in the same way, filled a small paper box. On opening the box, it was found that the exudation of chloride of iron had cemented the

slips with the oxide produced, and even the box had become saturated with the fluid. After the surfaces had been rendered perfectly bright by filing, and clean by copious washings, the slip was supported in a glass vessel containing a very dilute solution of red prussiate of potash. *The fluid did not exhibit any change of color;* but after the lapse of three hours, little dots of a blue color adhered to different parts of the bright surfaces. The dots soon became the bases of minute downy filaments, which, externally of a blue color, rapidly elongated and assumed the appearance of a most delicate blue moss. Twenty four hours after immersion, the slip was completely enveloped in long interwoven tufts of filaments, which spread in all directions through the transparent yellow fluid, forming an object of rare beauty. These filaments were tubular—*the interior of the tubes presenting a greenish gray color, while the exterior varied in shades from dark to pale blue;* clearly indicating that the *chloride of nickel forms a large part of the whole soluble matter.* Substituting solutions of gall-nut, prussiate of potash, and sulphydrate of ammonia, for the red prussiate, the existence of the mixed chlorides was finely exhibited, but without the beautiful appearances attending the action of the red prussiate solution. The plate, removed from the solutions and cleaned, was colored only at the cavities irregularly disposed, from which soluble matter had been abstracted. These cavities were precisely such as granular bodies would impress on a surface; no appearance of flaws or cracks was presented.

The masses of this meteorite possess within themselves the elements of the destruction of their metallic character, when freely exposed in the atmosphere of our earth; such an effect would rapidly follow the exposure of small pieces, but in larger masses the decomposition by oxidation of chloride of iron arrests the change. Each little conduit of hydrochlorate becomes closed, and a thick investing coating encases the bright metal within. In consequence of this *protection by partial destruction,* you have been able to make known the composition of this remarkable substance. Had the deliquescent bodies as they were formed acted on the metallic parts surrounding them, and been washed away by dews and rains, a mass would have been left *not different from our well known iron ores.* Considered from its relation to the elements of water as an *oxidizing agent,* chlorine has the

most active powers and affinities; its existence in this meteorite, *in the metalloidal form*, proves that in the region of space from which it passed, or on the planet from which it was thrown, *there is not only no atmosphere for the oxidation of iron, but no moisture for the decomposition of the chlorides.*

Analysis.—A mass of the meteorite half immersed in pure water was exposed in a jar to the action of moist air. The fluid which was collected in the water resulted from the decomposition of the chlorides of iron and nickel; all the chlorine of the fluid and that of the deposited crust of oxide, gave with nitrate of silver 325 parts of fused chloride = 80·18 chlorine. The oxide of iron dissolved in the fluid, when brought to the state of peroxide, weighed 64 parts = 44·37 iron. None of the nickel oxide was deposited with the iron oxide; that from solution weighed 100 = 78·70 nickel.

All these substances were pure, and no others could be detected. The mode of operating evidently destroys all definite compounds.

A slip of the meteorite, from the interior of a mass which had lost a part of its soluble matter, was rendered perfectly clear and bright; 43 grains were dissolved in weak nitric acid, excepting minute grains of bisulphuret of iron, weighing 1·030 grains. The solution afforded 51·830 grains of peroxide of iron = 35·936 iron. Besides the oxide of iron, oxide of nickel was the only base contained in the solution. When weighed in the state of peroxide, 6·920 were obtained = 5·446 nickel. Nitrate of silver had given chloride of silver, which after fusion weighed 1·586 = ·390 chlorine. The composition of this slip, thus determined, is

For 43 parts—		For 100 parts—	
Iron, . .	35·936	Iron, . .	83·572
Nickel, . .	5·446	Nickel, . .	12·665*
Bisulphuret of iron,	1·030	Bisulphuret of iron,	2·395
Chlorine, .	0·390	Chlorine, . .	·907
Loss, . .	0·198	Loss, . .	·461
	43·000		100·000

During the time the solution was taking place, a few minute scales of brown oxide of iron were observed, and the solution

* The proportions of nickel vary in different parts of the specimen; there being most in the interior of the mass where it has not oozed out.—C. T. J.

contained a trace of sulphuric acid, due to a slight oxidation of the sulphur contained in the pyrites. The relation of the quantity of nickel to that of the iron varies in almost every fragment. The chlorine of the piece analyzed, as in those which were the subjects of the following experiments, had been partially removed, but even the small quantity remaining was sufficient to destroy the metallic appearance of a fragment after a few months had elapsed.

The structure of the meteoric mass, as developed by the action of diluted acids, is that of a compound alloy. That part which in the form of scales and plates appeared as delicate lines, has a negative relation to the gray or amorphous part, from which it was supposed to differ in composition. In malleable metals we often find the impurities with a part of the metal forming an alloy, while the mass remaining is pure and frequently crystallized. It is I believe a chemical law, *that in all alloys two or more distinct definite or indefinite compounds exist.* The results of a large number of analyses made here accord with this view. The general process for studying the composition of alloys and metals is that of effecting a solution of one of the alloys, or the pure metal, under circumstances which allow the other compound to remain unacted on. Neutral metallic salts are the best agents, and the aid of a small sustaining battery is required in many cases. When the metallic solution has as a base the oxide of the predominating metal of the alloy, the transfer of pure metal from the solution corresponds rigorously to the quantity of pure metal dissolved from the alloy; the analysis in such a case is of the most beautiful and satisfactory character. In examining the slips of the meteorite, I used solutions of iron, silver, and copper, preferring the last, although the valued character of the determination of weight by substitution is lost.

A slip of the metallic mass in a bright and clean state was rendered positive in relation to a slip of platina, (which had been recently heated red hot,) by a small sustaining battery. Both slips were then immersed in a diluted solution of perfectly pure sulphate of copper. The surfaces of the iron slip preserved their gray color, while the slip gradually exfoliated and let fall scales of bright heavy metal. The platina electrode was covered by a thick coating of pure copper, and no gas was disengaged during the time of the experiment. In the solution some fine gray

scales produced turbidness, while the color of the solution had become greenish blue.

The weight of the iron or positive electrode before immersion was 101·50. After the action was stopped, it was washed and dried over sulphuric acid; the weight was 65·82, it having lost 35·68. The platina electrode weighed 52·76, and after it had been dried, with its brilliant coating of copper, 88·76; or an addition of 36·00 had been gained. After carefully drying the scales and plates of metal which had fallen, 6·49 were obtained. From 35·68 deducting 6·49, the numbers 29·19 represent the weight of metal and alloy which in this solution caused the deposition of 36·00 of copper. Taking the determination of Berzelius, 30·86 of pure iron would have been required in a neutral solution; I shall hereafter allude to the peculiarity of this action.

The positive part of the alloy dissolved, contained—

Iron,	34·012
Nickel,	1·274
Chlorine,	·394
	35·680

While in the negative, or undissolved alloy, the metals have the following relation—

Iron,	3·674
Nickel,	2·483
Bisulphuret of iron,	0·333
	6·490

Reduced to per centum proportions—

Alloy dissolved,	81·811	Iron,	77·137
		Nickel,	3·570
		Chlorine,	1·104
Alloy separated,	18·189	Iron,	10·297
		Nickel,	6·959
		Bisulphuret of iron,	0·933

Another slip from the interior of a mass was wholly decomposed; 29·64 grains dissolved, caused the precipitation of 36·42 grs. of copper. The negative alloy, weighing 6·78, contained—

Iron,	3·694
Nickel,	2·774
Bisulphuret of iron,	·312

In 100 parts, alloy dissoved, 81·755, Iron, nickel and chlorine.

" " alloy separated,	18·245	Iron, . .	9·940
		Nickel, . .	7·465
		Pyrites, .	·840

The unequal distribution of the negative alloy throughout the mass prevents the ultimate analyses of any two portions affording the same numbers; and it is not certain that only one negative alloy exists. When a silver salt, especially the sulphate, is used in the proximate analyses, some parts of the negative alloy become firmly plated with silver, indicating a mixed composition in the alloy.

Your discovery of chlorides in this wanderer from unknown regions is a fact of interest, not so much on account of its adding more to the number of the constituents already known to belong to meteorites,—its significance and importance in my view are rendered more prominent, by their direct relation to a state which a part of our earth might once have exhibited; favoring the conclusion that the chlorides and hydrochlorates of our rocky strata may have resulted from the decomposition of metalloidal chlorides existing with the metallic bodies from which our rocks have been formed, the presence of our atmosphere and moisture being sufficient to destroy a state of repose and carry it to the one of constant changes which we observe.

With high regard, A. A. Hayes.

Roxbury Laboratory, November 1, 1844.

Art. XV.—*Effect of a contracted space in obstructing the Vibrations of a Mercurial Pendulum;* by George Baker.

While adjusting a mercurial pendulum, last autumn, which I put to my regulator, I had occasion to observe closely the changes in the arcs of vibration, which led to some investigation of the cause. I found that during the last three days of the descent of the weight, the vibrations were diminished 0° 6′ on each side of the point of rest, which I attributed to the near approximation of the weight to the ball of the pendulum, causing an obstruction to the displacement of the air by the motion of the pendulum, and as I anticipated, caused the clock to *lose* during this portion of the weight's descent, whereas during the other portion, when

the weight was above the ball, it *gained* about as much. The time of winding is Saturday evening, and the bottom of the weight reaches the top of the jar of mercury on Wednesday morning, and descends about four inches, or half its length, below it, before the time of winding; passing within about five eighths of an inch of the side of the jar and in a line with it. I found that on winding up the weight, the vibrations would attain their usual length (1° 20′) in about thirty minutes. I found also, that by opening the door of the clock when the weight and pendulum ball were in conjunction, the vibrations would immediately increase and soon extend to 1° 30′.

Further confirmation of the evidence that these changes were caused by the obstruction in the passage of the air, was furnished when I had occasion to take out the glass door of the clock and put in one of wood, (temporarily,) which diminished the distance from the ball of the pendulum from three fourths to one fourth of an inch. This change caused a decrease in the arcs of vibration, of 0° 12′ on each side of the centre, and a loss in time of three seconds daily. On replacing the glass door, the usual vibrations of 1° 20′ were resumed, and the time corrected.

It is well known that the velocity of steam vessels and canal boats is much diminished, by shoal water in narrow passages, where the escape of the water displaced by the boat, is obstructed on the same principle by which the weight of a clock obstructs the escape of the air displaced by the motion of the pendulum, when confined in a small space.

It may be well to state, that the jar of my pendulum is eight inches in depth, and two inches in diameter inside. The column of mercury is seven inches, and the weight of the whole, with the rod and jar frame, is twelve pounds. The weight is of lead, cased in brass; length, nine inches and five tenths; diameter, one inch and four tenths; shape, round; weighs five pounds and three ounces, and is suspended by a double line and pulley. Depth of the clock case in the clear, five and a half inches; width at the centre of oscillation, fourteen inches; and extends below the bottom of the jar three inches.

Since recording these observations, I have read a chapter in Read's Treatise on clock and watch making, on pendulums, (which I had overlooked,) where I find an account of similar experiments, although the influence of the weight on the motion

of the pendulum, is not explained on precisely the same principle which I had adopted.

In another chapter in the same volume, the effect of the weight when opposite the pendulum ball to lessen the arcs of vibration, is attributed to mutual attraction, by some artists, and by others, to the motion of the weight communicated by the pendulum, and acting upon it reciprocally.

So far as I have had opportunity to extend my inquiries among practical horologists, I have found that the effect of confined air, and especially the influence of the weight on the motion of the pendulum when opposite the ball, and near to it, have been very little known or regarded.

On this account, perhaps the publication of these observations may be of some importance, and may elicit a valuable communication on the subject.

Providence, June, 1843.

ART. XVI.—*Description of Fossil Footprints in the New Red Sandstone of the Connecticut Valley;* by JAMES DEANE, M. D. (With a plate.)

THE impressions illustrated by Plate III, are footprints of extinct quadrupeds, from the new red sandstone of Connecticut River; vestiges of unknown animals, of whose affinities we have no other knowledge than what is derived from analogical science. But the geological position of this rock assures us that the epoch in which these inhabitants of an infant planet lived, was immensely remote, and this antiquity alone invests them with extraordinary interest. To see upon the smooth stratified rock the successive steps of extinct animals, indisputable and imperishable, sunk like a die, more perfect and inconceivably more enduring than the proudest achievements of human skill, is a sublime spectacle, because it creates the sentiments of sublimity and awe. The history of fossil footprints, although of recent date, is replete with amazing facts, yet we seem to have just entered the vast regions of inquiry, for new developments are constantly unfolding, some remarkable for grandeur of proportion, and others for exquisite beauty and preservation.

The successive steps of three individuals derived from distinct localities, are grouped upon the plate, which at first view imparts to it a crowded appearance; but a slight examination will rectify this apparent confusion. Fig. 1 is a course of consecutive footsteps, accurate in size and order of occurrence. Fig. 2, alternate impressions, in their natural relations of size and place. Fig. 3, also alternate impressions, but not in their relative order, the capacity of the plate being inadequate to that design. These footprints are drawn with elaborate care, and may be relied upon as being, in a very high degree, correct copies of the originals.

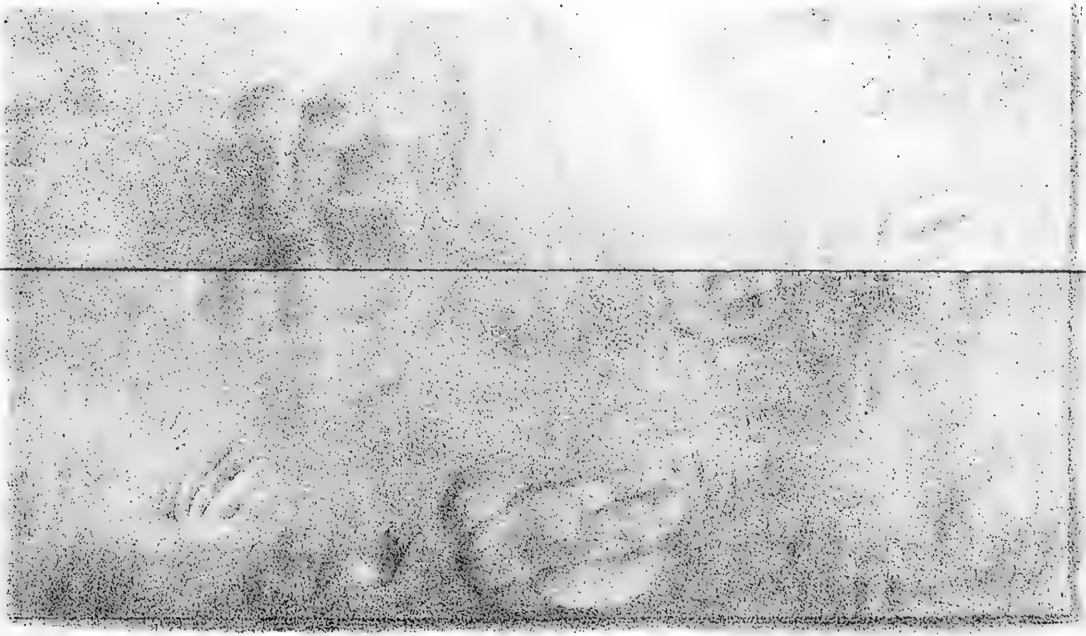
It was not until six years after the *ornithological* footsteps upon the same rock attracted my attention, that I discovered these cotemporary impressions, notwithstanding vigilant search had been made during this interval. The disclosure of several species of reptiles in the equivalent rock of Germany and England, rendered it nearly certain that sooner or later the vestiges of kindred animals would be found upon our own strata. Prof. Silliman, in his anniversary address before the Association of American Geologists in 1842, remarked, "that it was certainly possible (speaking then of Ornithichnites) that among the impressions of this period, if not among those already discovered, may be found some of the Batrachians and Chirotheria of England and Germany." I had previously submitted to Prof. Hitchcock an example of anomalous tracks from Turner's Falls, (fig. 1,) which he conjectured might be those of a quadruped. But up to this year no corroborating evidence appeared to sustain this belief, and Mr. H. meanwhile published an account of them in the first volume of Transactions of American Geologists, including them, however, in his order Dipodichnites, or bipedal footsteps.* But recent explorations have established the quadrupedal origin of this example, by the concurrent discovery in adjacent localities,

* The language used by Prof. Hitchcock, after describing the above impressions, fig. 1, (see his figure 9, Pl. XI, and description, Proceedings of Assoc. Am. Geol. p. 262,) is: "The probability therefore is, that this is the track of a quadruped. Indeed its appearance is like the track of a four-footed animal. Yet it differs from the Chirotherium in having only three toes beside the thumb. Still the shape of the toes corresponds well to those of the Chirotherium. If I am not mistaken, then, this is the first example in which I have any certain evidence that any of the numerous tracks upon the sandstone of the Connecticut valley were made by a quadruped: though as will be seen by reference to my Final Report, I strongly suspected such might be the case in respect to several of them."—Eds.

of those varieties represented by figs. 2 and 3, and Mr. H. has consequently arranged the original in the order Tetrapodichnites, a term signifying *four-footed tracks.*

A critical inspection of the several footprints delineated upon the plate, discovers a general similitude, although the contrast in magnitude is so considerable. The comparison is most intimate in those examples represented by figs. 1 and 3, the toes being pachydactylous, or stout, short and blunt, lying in contact, and diverging but slightly. In fig. 2, these members are comparatively long and slender, or leptodactylous, much separated, yet fall in nearly parallel lines. In two instances only are the toes surmounted with claws, which appendages are short and pointed. But the disagreement between figs. 1 and 3, and fig. 2, is obvious in length of stride, that of fig. 2 being equal to fig. 1, while the foot is not one fourth as large. This disproportion alone separates the animals, by which the respective impressions were made, into distinct species. The small imprints cannot be referred to the young of the larger animals, because, on this hypothesis the length of step would be in correspondence with the diminished size of the individual. The route of fig. 2 is nearly in a direct line, while in fig. 1 it is irregular or tortuous, which explains the advanced position of the fore feet in this instance. In both fig. 2 and fig. 3, the fore feet fall a little within and a little in advance of the hind feet, and this is the natural order in several other examples which I have seen, the two impressions being nearly in contact. The identity of the impressions is further maintained by the equal distribution and arrangement of the toes, each foot having three pointed forward, and a stout thumb standing obliquely inward. The difference in point of size between the hind and fore feet, and the divergence of these organs, are general peculiarities. In fossil footmarks of birds the central toe almost invariably points in the direction nearly, of the succeeding impression of the opposite foot, or the axis of the foot is in reverse order to that of the quadrupedal members.

The impressions represented by figs. 1 and 3 were unquestionably produced by identical animals. They display the same massive toes and other affinities, the distinguishing difference being that of size. In numerous examples of this variety, holding an intermediate grade in respect to proportion, the same broad tarsus and fleshy toes exist; but as has already been intimated, the



J. Heine del

Footmarks of unknown animals from the Stratified Sandstone of Turner's Falls, near Greenfield Mass

J. Deane del.

Footmarks of unknown animals from the Stratified Sandstone of Turners Falls near

distinction between this variety (denominated *Batrachoidichnites Deweyi* by Mr. Hitchcock) and that marked fig. 2 is so manifest, that they are at a glance seen to be dissimilar.* The slender toes and disproportionate length of stride of the latter variety are peculiar distinctions. In the great number of Ornithichnites I have studied, I do not remember an instance where this disproportion of the feet and stride was so unequal. The shortest step of the sandstone bird is rather less than that of this diminutive quadruped, while the area of the foot is several times greater; hence the four-footed animal, although extremely small, must have been elevated upon legs bearing a corresponding relation to its attenuated toes. These quadrupeds, congregating promiscuously with the ancient birds, probably derived the materials of their support from the same element; and it remains to be considered whether the extinct species have their representatives in the living, or in other words, whether from the arrangement and configuration of the impressions, the natural affinities of the ancient animals can be determined by comparison with those that now live.

This problem can only be solved by applying the potential law of correlation of function. If the dental or osseous systems could be obtained, the restoration of the animal would not be a difficult task in competent hands; and with the perfect cast of its foot, it would seem that a conclusion almost as satisfactory might be reached; for the fashion of an animal's foot is an indication of its character scarcely less valuable than the peculiar structure of the teeth and bones. The mutual correspondence, or the indispensable relation between the several systems uniting to execute the designs of organization is so unerring, that by the discovery of one organ the others are inevitably indicated. The footprints of all animals with which we are intimately acquainted, irresistibly lead us to determine the kind making them; and this principle is so universal, that if we can find an existing animal whose footprint shall resemble the fossil impressions, we may conclude that there is a necessary resemblance throughout the entire organization of both animals. When the footmarks

* The resemblance of Dr. Deane's figure to that given by Dr. Hitchcock of his *B. Deweyi* is certainly very strong. Compare fig. 10*a*, Pl. III, p. 308, Vol. XLVII, of this Journal, with the figure by Dr. Deane accompanying this article.—Eds.

of birds were discovered in 1835, their resemblance to the feet of existing birds was so palpable, so absolute, that their origin was instantly recognized; and when the celebrated footsteps upon the sandstone of Hildburghausen were discovered about the same time, the laws of analogy were applied to solve the mystery, which resulted in the belief that the animal by which they were made had its type in living species, and this opinion was not long after fully corroborated by the discovery of the animal's bones. In fact, as the teeth of animals indicate the feet, and both teeth and feet indicate the intermediate organs, it is a sound conclusion that the order may be reversed—viz. the feet may indicate the teeth, and consequently the several organs that constitute the animal economy.

It is fortunate for the investigation of these unknown footsteps, that the exact knowledge concerning the German impressions is available in arriving at a satisfactory conclusion; for the resemblance between these remote examples is perhaps as complete as will be found upon comparison with the feet of living animals. This resemblance, aside from the vast disparity of size, is intimate; the main distinction consisting in the unequal number of toes, the American specimens having four and the European five each; a difference which of itself only separates them into species, the essential type still existing in each. But the peculiar similitude, and the most apparent and indeed most valuable, is the disproportion in respect to size between the anterior and posterior feet. The latter are thrice greater than the former, and this distinction points to the living type which is found in the Batrachian order of reptiles; or possibly it may exist in the lowest grades of mammiferous animals, the same inequality or lack of symmetry being also observed in them. Viewing these sandstone vestiges to indicate either class, and associating them with ornithic impressions, the laws of analogy refer the animals by which they were made to the condition of those existing species which are supposed to be their representatives. It is a doctrine now well established, that the remarkable footprints of *birds* are due to aquatic varieties allied to existing Grallæ or waders—birds inhabiting margins of waters, and traversing muddy shores and shallow bottoms which were alternately submerged and exposed to the sun's action. The existing Batrachians and numerous kinds of the Grallæ occur promiscuously,

and derive their subsistence from a like littoral origin, and thus concur to demonstrate the affinities of their ancient progenitors. Hence too this view supplies a palpable illustration of the immutability of Creative Design; for the individuality of entire races of animals is thus proved to be perpetuated through a period of time too vast for comprehension or even conjecture; and although living forms have been modified by the force of external influences, still the essential truth indicated by these astonishing remains stands out in bold relief. This is but a single exemplification of the eternal laws that rule the material universe, as revealed by the science of geology; but every indication of past life impressed upon the enduring rocks is an irresistible truth, which eloquently records a page of the earth's history before it came under the dominion of man.

The relative disproportion of the feet of these extinct animals does not comprise the only feature upon which a comparison can be instituted; the identity exists also in the configuration and arrangement of toes, which appear to sustain the same character in reference to structure. They are massive, the thumbs stand in the same oblique direction, and the impressions upon the plate only lack the fifth toe to sustain with those of the Chirotherium* a harmonious relation, strengthening the presumption that the animals by which the several impressions were made were members of the same family. This conclusion furnishes a geological principle of importance in establishing also the analogy of the rocks upon which the several examples of footsteps, American and European, occur. The identical nature of organic remains supplies a beautiful law to prove the analogy of remote geological formations; and not only do these footprints, but several varieties of vegetable impressions, and impressions of fishes and other important fossils, concur to sustain this principle.

It is to be regretted that in investigating this obscure subject, the facilities of illustration by recent footsteps of Batrachian rep-

* I adopt this term because it is intimately associated with the German impressions. It is however well known that the animal by which it is believed these footprints were impressed is now denominated by Prof. Owen *Labyrinthodon*, from the intricate structure of the animal's tooth. "I can never forget," says Dr. Mantell, "the astonishment and delight with which Dr. Buckland, Prof. Agassiz and myself observed for the first time the marvellous structure of the tooth of the Labyrinthodon, displayed to us by Prof. Owen before his splendid discovery was communicated to the scientific public."—*Medals of Creation*, p. 788.

tiles are inaccessible. But it is hoped that these discoveries will attract the attention of naturalists who have given to the study of this class of animals particular attention. In illustrating the meaning of these new fossils, the difficulties to be encountered are superior to those connected with ornithic imprints. With the great class of birds we become insensibly familiar by constant association; but the natural element of the Batrachians, their obscure retreats, and the meagre opportunities of seeing the imprints of their feet, are obstacles which combine to baffle accurate comparisons. The progression of all birds when moving upon the feet is by the same method nearly, but in the cold blooded amphibious Batrachians there is in this respect considerable diversity. In frogs, toads, &c. it is by a rapid succession of leaps; while in salamanders, lizards, and the like, the method is by walking. This is the case with the German footsteps and those now under consideration. Yet, as has been intimated, when we become as familiar with recent footprints of Batrachians as we now are with those of existing birds, the true relations of the extinct varieties can be determined. The affinity of the American and German examples is sufficiently intimate to remove all doubts of their mutual relations; but in the absence of bones, of which no instance has yet occurred in the stratified sandstones of the Connecticut River, we must not omit when opportunities occur, to institute comparisons with the footprints of those living animals that appear to be most nearly allied to them. It may be safely asserted upon this principle, that the quadrupedal impressions from Turner's Falls are those either of Batrachian reptiles or of marsupial mammalians, of which two distinct species at least exist, and most probably three, as will be directly seen.

It is the design of this article to communicate facts rather than to draw the necessary inferences; and with this view I have been at considerable pains to prepare an accurate plate, which the Editors have deemed sufficiently important to justify the expense of publication, and to this drawing I would respectfully invite the particular attention of those naturalists whose opportunities or pursuits may lead them to explore the laminated beds of new red sandstone. Upon the Connecticut River localities especially, and doubtless in most others, the *minute* traces of animals can be detected only by vigilant attention; and the

most favorable time is when the sun's rays fall obliquely upon the stratum and project a shadow into the shallow depressions.* I do not find them, except upon smooth surfaces—a fact indicating that the sedimentary elements of the face of the rock were deposited when nearly in a soluble state, and that the impress was made at the favorable period when the drying process allowed the impression to be most perfectly taken as well as retained. Ichnolites are frequently associated with rain-drop impressions, and I have always observed that when these are perfect, the animal vestiges are remarkable for beauty. I observed during the past summer where a pool of water, the result of a shower, had gradually subsided, the surface of the earth was coated with a thin, shining, plastic sediment, which at first did not retain impressions; but in a few days a slight shower pitted the surface completely, and footprints of frogs, birds, and dogs were exquisitely retained, illustrating with great force the exact process whereby ancient footprints were impressed and preserved. I removed samples containing both rain-drops and footprints, which are now in my cabinet, and are of the solidity of unburnt brick. I allude to this subject because it is important to the observer; it is a guide that may possibly save him from fruitless toil. As a general thing, a smooth glossy surface free from grit is most promising; while coarse masses with granular surfaces, even though stratified, are usually barren. The habit of observing correctly can be acquired only by labor, and these hints may not be useless in a practical sense to beginners in discriminating between the conditions that indicate the probability of success or the certainty of disappointment.

My collection of ichnolites for the past year has not been extensive, yet it comprises examples of peculiar interest. I have with Mr. Marsh obtained from a locality thirty miles distant from

* Since this article went to press, in examining a slab of superb Ornithichnites, by *candle light,* I was surprised to discover two rows of extremely minute impressions which had hitherto escaped my observation. When the rays fell in a direction nearly horizontal, the impressions were perfectly distinct. Both examples were those of quadrupeds of the delicate variety illustrated by fig. 2 upon the plate. One of them consisted of five impressions corresponding in size and stride with fig. 2; but the other consisted of seven pairs of impressions, not one half as large, the stride being only three inches. This is by far the most diminutive example of fossil footmarks yet discovered, requiring a magnifying power to appreciate it correctly. Upon another portion of the same stratum was an example of this variety twice *larger* than fig. 2, distinct, with a stride of seven inches.

Turner's Falls, a specimen of *Ornithichnites giganteus* of stupendous proportions, the impression being no less than eighteen inches or half a yard in length, from the outer circumference of the tarso-metatarsal bone to the extremity of the central toe, and fourteen inches between the extremities of the lateral toes. The line of footsteps uncovered consisted of seven successive impressions, all of the same colossal dimensions; but three of them were sufficiently strong to be removed without being shivered to pieces. The impressions of the shank bone and of the several articulations of the toes are quite distinct, and each impression is sufficiently capacious to contain half a gallon of water. What was the real magnitude of this fearful bird? He maintained his supremacy throughout the entire period of the new red sandstone deposition, while other varieties, though gigantic and powerful, became extinct. He was endowed with a physical frame fitted to endure the turbulence of the era in which he reigned the supreme monarch of his race, and was finally exterminated only by the all-prevailing catastrophes that swept from the earth other vast creatures which were his cotemporaries but not his conquerors.

Among these discoveries are two new varieties or Ornithichnites. One of them six inches in length is remarkable for the extension of the outer or long toe *backward*, three of the four joints being posterior to the first joint of the middle toe, which is anomalous. The slab contains a right and left impression. I have also discovered a row of singular impressions which I suppose to be those of a crustacean. They are about one inch and a half in length by half an inch in breadth, rounded at the extremities, shallow, but exquisitely perfect. They are placed obliquely, but are parallel with each other, and in this respect resemble one of the rows in Prof. Hitchcock's plate, published in this Journal, Vol. XLVII. I had not seen these plates at the time I discovered the specimen; and I broke it from the rock without any idea of the origin of the impressions, and unfortunately only removed a single row. I have since searched for its locality with great care, but have been unsuccessful in discovering the precise spot whence I obtained it.

Since the preceding remarks were written out, the quarrymen in my employment have recovered several interesting slabs at Turner's Falls, containing beautiful impressions of rain-drops,

and of several varieties of birds. But the slabs also contain evidences of a new *quadruped*, whose foot was two inches long and consisted of *five* toes. The impressions are numerous and distinct, showing the tuberous expansions of the joints, and in some instances the terminal claws. But I have given the impressions only a hasty inspection, and cannot be more definite until they have been thoroughly considered. Every visit to the sandstone quarries discovers something new, and proves that this rock, which has until recently been considered to be nearly destitute of the indications of organic life, except of fishes and a few lignites, is rich in the evidences of ancient life. For some reason not understood, this rock is unfavorable to the preservation of bones of animals; but it renders a full equivalent by retaining the exquisite impressions of their feet, and in some instances of their bodies. It is a mine of knowledge; beyond the signs of life hitherto described, many others are apparent, too vague to be compassed by any laws of comparison that have yet been applied to them.

Note.—I cheerfully take this occasion to correct a statement in my rejoinder to Prof. Hitchcock's reply, (Vol. xlvii, p. 401,) which does that gentleman unintentional injustice. In alluding to the labors of Mr. H. in developing the history of footmarks, I remarked that he was amply compensated therefor by virtue of holding a geological commission from the state of Massachusetts. I believed this to be strictly true; but since the publication of the controversy, I have received a note from him stating that his first commission expired in 1833, and that his second was received late in the summer of 1837; consequently for *three* summers after the first discovery in the spring of 1835, he was not in the service of the state. This explanation is due to Mr. H., and the mistake would have been corrected in the proper place if Mr. H. had not accidentally failed to receive a proof of my piece.

Greenfield, November 20, 1844.

Art. XVII.—*Reply to a Notice of Shepard's Mineralogy, with various Mineralogical Observations;* addressed to Mr. B. Silliman, Jr., one of the Editors of the American Journal; by Charles Upham Shepard, M. D., Professor of Chemistry in the Medical College of South Carolina.

Remark, by the Editors.—It must not be inferred from our admission of this communication, that we recognize the right of authors to reply through *ourselves* to any critical remarks which may be made by the editors of this Journal upon their published works; unless it can be shown that we have failed to apprehend or have incorrectly stated their views.

We are well satisfied that our remarks should have called out from Prof. Shepard a defence of his views, since by a comparison with the objections offered, our readers may be able to form a more unprejudiced opinion of the real nature of the pure natural history method. He says,—

In your notice of the new edition of my Mineralogy, while speaking favorably of my merits as a cultivator of American mineralogy, you have been pleased to bring forward several objections to the principles upon which the system in that treatise is constructed. As that method is the one according to which I have heretofore conducted my mineralogical studies, you will not think it strange that I am anxious to do away if possible the force of your objections, while I feel that it is, in some measure, demanded of me also, if I would retain the character your notice still leaves me in possession of, as ranking among the most successful cultivators of the science in the country.

I hold mineralogy to be simply a branch of natural history, that general department whose business it is to perform for the three great kingdoms of nature (the animal, the vegetable, and the mineral) the following services: first, to point out and designate by suitable terms the natural properties belonging to the various objects in each kingdom, (*terminology;*) secondly, to settle the grounds of classification, (*theory of the system;*) thirdly, to affix names, (*nomenclature;*) fourthly, to furnish a set of marks to enable the learner to determine unkown objects, (*characteristic;*) fifthly, to provide for each species a full description of its

properties, (*physiography;*)—it being understood throughout, that the natural properties, viz. those neither manifesting any change in themselves, or leading to any in the substances which possess them during their examination, are the sole objects of attention. In this manner are obtained three independent sciences; viz. zoology, botany, and mineralogy, differing from each other in the natural objects to which they relate, while each by itself, proceeding from a comparison of natural historical properties, gives rise to a collection of homogeneous information, and on this account strictly conforms to the logical idea of a science.

It is plain that mineralogy thus developed has all that is necessary to make it a science, inasmuch as it is wholly distinct from other sciences, and possesses the requisite singleness of aim and means, in respect to minerals,—its sole province being to illustrate their natural properties, and thereupon to name, classify, distinguish and describe the species.

If mineralogy as I have defined it may be a science by itself, I see not why in the study of minerals, it may not be equally useful as are the correlative branches of zoology and botany in the study of animals and plants. The objection that "there is a wide and irreconcilable distinction between the results of vital force in the production of organized forms and those of molecular attraction which govern the characters of crystallized minerals," lies only as it seems to me against the possibility of minerals being treated natural-historically, but does not show, in the event of its being practicable thus to consider them, that the advantages supposed, would not result to the investigation of minerals. But that this difference of dynamics operates unfavorably to the natural history treatment of mineralogy I deny; and claim on the contrary, that the variety and constancy exhibited in the properties of minerals in consequence of the very absence of life, render those properties peculiarly available for the purposes in question.

If you should still object that my method injuriously restricts the science, and prefer the ancient definition which allows to mineralogy every sort of information which relates to minerals, I have only to say, that when you have applied the same definition to zoology and botany, you have extinguished nearly the entire circle of the modern physical sciences, and reduced all our knowledge of external things into three vast assemblages, which from

the magnitude, no less than from the heterogeneous character of each, would well nigh discourage the efforts of the most herculean intellect.

It is on these grounds then, that my treatise makes a distinction between mineralogy, and the full knowledge of minerals; and with this in view, you will see that I have no necessity to employ chemistry in "the determination and arrangement of minerals," not even "when it is corroborative of natural history," while at the same time, I am far from denying the importance of the knowledge which may be acquired by chemistry. I do indeed banish the blowpipe and analysis from mineralogy, though I am free to admit that I often resort to the use of both, but never under the idea that I am then mineralogically employed, any more than I would hold you to be zoologically or botanically so, if you were analyzing feathers or rice.

Having now as I trust fully shown that the treatise by no means disallows the chemical study of minerals, although it does not recognize the results of chemistry as forming an integrant part of mineralogy, it is unnecessary for me to remark any farther on this head, than merely to say, that I do not take you to be in earnest, when you assert that a student who should prosecute the study of mineralogy on the natural history system, might with equal profit study a cabinet of glass of divers hues, since that would be to assert that a treatise composed on the plan in question, is occupied solely with the unimportant property of color.

Difference of composition in the case of quartz and diamond is not then, as you seem to suppose, an accident with me, as an inquirer into the whole nature of these minerals, but only so far as I am a special mineralogist. I do indeed know quartz from diamond on the grounds you mention, if by knowing them you refer (as is supposed) to the power of distinguishing one from the other: and surely you will not deny these grounds to be both consistent with my system, and sufficient for the purpose. But if you intimate, that I would have the general student of minerals rest in the mere names determined natural-historically as a full knowledge of minerals, I reply that you misapprehend the structure of the treatise under consideration; because it refers the pupil, who has by means of it learned the name of a mineral, forward, to a general work, devoted to physiography, where he may find an enumeration of all the natural properties belonging

to the species, and to which is affixed in separate paragraphs and usually in smaller type a variety of other information drawn from other sciences and here collated, not because it belongs to mineralogy, but for the convenience of the student, who would otherwise be obliged to refer for it to numerous, independent works.

You observe in the next place, that "chemical characters alone are perhaps as insufficient as characters purely physical, in the determination of minerals." It is perhaps impossible to settle this point from the history of the science, since it has scarcely ever been attempted; the practice rather having been to employ both sets of characters together, sometimes leaning more to one side and sometimes more to the other. But to myself, it has always appeared that the uncertainty has been just in proportion to the preponderance allowed to the chemical side; while if even a parity in point of conclusiveness between the two methods could be established, I should yet claim that the pure method should be adopted in preference to the mixed, not merely on the score of logic, but also because it neither presupposes a knowledge of chemistry, nor leads the student to a harmful neglect of the natural properties of minerals.

You observe that "to the chemist, rutile and anatase, Sillimanite and kyanite, white iron pyrites and iron pyrites, carbonate of lime and arragonite, garnet and idocrase, are identical substances." It is true that in the present state of chemical science we are obliged to regard these sets as identical, unless the new research of GLOCKER* relative to one of the supposed varieties of white iron pyrites should lead to a single exception in the list; but be that as it may, all allow these substances to be different in mineralogy, in virtue of the non-identity of their natural properties, and not as you remark by the laws of dimorphism; for the principles of this modern branch of physics do not establish it as absolutely certain that among many dimorphous bodies any such change of hardness and gravity attends that of form also, as would necessarily lead to the establishment of distinct species, in the case of dimorphous minerals.

But not only do you object to the principle on which the practical or determinative part of the work is founded; you allege also, that the tables "are too brief to enable the learner, who is unacquainted with the science to determine a species with facil-

* Pogg. Ann., LV, 489.

ity," which obliges me to attempt their vindication from this new attack against their sufficiency; for it may be recollected that the first edition of the treatise brought down upon my characteristic numerous objections from Prof. Del Rio, which I endeavored to controvert in Vol. xxvii, p. 312, of this Journal. In proof of your charge you merely cite the specific character of apatite, following it up by this single observation, "This is all the information which the author thinks necessary to enable the learner to determine this species." But in making this charge, you overlook the characters I have also given, in their proper places, for determining the class, order, and section, respectively, to which apatite belongs. You must be aware that my characteristic is no more liable to the charge made, than would that in botany be, because the usual specific character for the *Cornus Canadensis* (which is "herbaceous, leaves at the top whorled, veiny, involucres ovate, acuminate, fruit globose") is insufficient for its determination. In both cases it is alike required that the characters for the higher ideas in the system be first availed of, beginning with the most comprehensive, and descending, *gradatim*, to the species.

Before then you can affirm that my tables for determination are insufficient, you must show that a student with an individual of apatite in hand, after the use of the appropriate means for learning its form, hardness, and gravity, cannot by the rules given refer it to its appropriate species. When this is done, you will have demonstrated the failure of my characteristic in respect to one of its 343 species.*

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* I should be less anxious to vindicate the practical part of the treatise from the force of your objection, did I not suppose it to be the most original feature of the production. Indeed, it was the construction of a characteristic analogous to those employed in zoology and botany, which first led me to become a writer on this science; and I may perhaps be allowed here to state the peculiarity of my method, as the subject is one of admitted importance, and respecting which my first reviewer (Del Rio) remarked—"the mere attempt to solve a difficult problem is in itself worthy of praise, although the method be complicated, because it can be subsequently simplified." This method has been greatly modified in the second edition, although its principal feature is still retained, which is that of distributing minerals into classes and orders on some general grounds, and then arranging the contents of the orders in a series depending on hardness, placing the softest first and ending with the hardest species; the hardness of each being given by the scale of Mohs in a column immediately to the right of the names for each species in the list. Adjoining this and on the right again, is appended a column containing the gravities of the species; and whenever it is supposed that these two prop-

After what has been already said, it is unnecessary to attempt to show that the little volume under consideration ever was intended "to go alone as a complete treatise." It does not even advance to the most voluminous department in mineralogy, viz. the descriptions of the species; much less does it pretend to collect from other sciences the contributions they afford, in order to complete our knowledge of minerals.

The review charges me with an inconsistency on the ground of nomenclature, for using Count BOURNON's name *fibrolite*, (which it declares to be obsolete,) while I at the same time set aside a number of well established names to make room for those of my own construction. But it is impossible that the name Fibrolite can in any proper sense be said to be obsolete. It is indeed true that it was applied some time ago to a scarce substance, which until lately, was rarely seen in our collections and consequently but seldom referred to in the books, although its description has been constantly repeated in all mineralogical authorities. On what ground then could it be thought that I should drop this

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erties will not lead to the name sought, other information relating to form, structure, fracture, lustre, &c. is added, in a column still exterior to the first.

As the foregoing method was contrived with a view to bring minerals under a determinative process, analogous to that practiced in botany, (see Treatise, first edition, 1832, p. 138,) it is plain that the claim lately put forth by BERZELIUS in behalf of M. NORDENSKŒLD, that he was the first person who has made this attempt, is not well founded.* The title of this latter work is "*Utkast till ett examtinations system för mineralierna;*" and BERZELIUS says of it, that it is the first work ever published which has it principally in view to enable beginners to determine the species of minerals, as the sexual system of LINNÆUS does, in the case of plants. (*Rap. An. Prog. de la Chim.* 1844, *p.* 144.)

* A similar method was employed as early as 1771 by Dr. John Hill in his Mineralogy, entitled *A work on Fossils, arranged according to their obvious characters, with their History and Description under the articles of Form, Hardness, Weight, Surface, Colour and Qualities: The place of their Production, their Uses and Distinctive English and Classical Latin Names.* 8vo. London, 1771. As the work is of considerable interest in the history of the science, especially of the *natural history* method, we give the following quotations from the preface.

"From these determinations alone of our senses, will be given a detail of the differences we find in fossils, under the heads of Form, Hardness, Weight, Surface, Colour, and Qualities, as distinguished by the taste, smell, or touch. These distinctive marks will be disposed separately in so many columns; and to these will be added two more for the *history* of the bodies, comprehending the place where they are found and uses to which they serve. Thus the few words in our six first columns read together, will give the specific character of every fossil." "The purpose of the book" is declared to be, "to lay down an arrangement of fossils; founded on their obvious characters and sensible qualities, according to which they may be known and disposed in method, without the skill of Chemistry, or the fatigue of Experiments; without furnaces or aqua fortis." The plan here indicated was carried out as perfectly as the state of the science then admitted. The Preface is a very lucid and philosophical exposition of the views taught by the school of the German mineralogist, Mohs. B. S. Jr.

trivial name for the more recent one of Bucholzite, which had erroneously, as it now appears, been given to the productions of another locality?

Of the new names charged to my account, Kraurite is BREITHAUPT'S, while Selbite and Carinthite are both BROOKE'S, the latter given to render the trivial nomenclature uniform, and especially for excluding purely chemical names. I plead guilty only to Oxacalcite and Beresofite, both of which were offered in substitution of chemical designations, in accordance with the allowed rule that every mineral species is entitled to a trivial name.*

Finally, the review sets it down as evincing the incorrectness of my principles, 1st, that I have brought forward on natural history grounds, the following ill constituted species, viz. Quincite, Lincolnite, Goshenite, Lederite, and Washingtonite; 2dly, that I have also erroneously proposed Chathamite, though on a chemical basis; and thirdly, that I have done the same again in the case of Danburite, though you are not wholly sure whether this species is claimed in behalf of natural history or chemistry. To exculpate the treatise from the latter charge, it is enough to say, that it does not claim it in any sense whatever to be a species—a mode of vindication which also extends to Lincolnite, Lederite, and Washingtonite, the names which are numbered only, being supposed to rank as species, and neither of these four names being preceded by this token of specific character.

The difference between us then, narrows down to the instances of Quincite, Goshenite, and Chathamite.

Of *Quincite*, I know of nothing which can be said to its disparagement as an independent species. The name *Meerschaum*, (sea foam,) under which you intimate it might be included, is generally esteemed to be a geological compound, rather than a mineralogical species.

I agree that *Goshenite*, in the absence of well determined crystals, rather than for the want of a good analysis, (as you suggest,) occupies a precarious position among my list of species. Still as you appear to feel a degree of hesitancy yourself, in referring it back to beryl, where it was first placed by Col. GIBBS, and as I know this hesitation is shared by some of the best European

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* Did the trivial name *crocoise*, [as the name *crocoisite* was already in use, (made from Beudant's *crocoise*,) it was the less necessary to propose another synonym, B. S. Jr.] proposed by BEUDANT for chromate of lead, possess a termination more in accordance with our other names, I should not propose Beresofite in its place.

mineralogists, I trust that you will not allow this possible error, to have too much weight in deciding either against the principles of the treatise, or the general success with which they are reduced to practice.

Chathamite was put forth as new, not for chemical reasons, as supposed, but simply from a difference of specific gravity between the Chatham mineral and white nickel. I may also add, that a degree of negative evidence still weighs in my own mind in favor of the correctness of the opinion, arising from the fact, that the mine though explored for months for this ore, has not as yet afforded a single specimen which shows the crystalline form to be identical with that of white nickel, as might have been expected, provided the relationship you suppose, exists.

In conclusion I have only to remark, that I regret taking up the pages of this Journal, devoted as it is to the records of American science, with the present rejoinder; but the unfavorable position in which your criticisms were calculated to place my treatise, appeared to leave me no alternative on the occasion, either as I valued my scientific reputation, or those systematic views in mineralogy, which have commended themselves so strongly to my understanding.

2. *Various Mineralogical Notices.*

1. *Quincite.*—I find the variety with a conchoidal fracture to possess a hardness=6·0, and a gravity, from 2·05 . . . 2·30.

2. *Lincolnite.*—It is suggested by the editors of this Journal, (in the last number, p. 416,) that the angle 116° 45′ . . . 117° 15′, obtained by me for the inclination of the lateral faces of the Lincolnite, is simply that belonging to a secondary form of Heulandite, in which the plane replacing the acute lateral edges, is so far produced as to extinguish the shorter faces of the primary, since such a supposition only has to account for an error of 2° 15′ . . . 2° 45′, which it is supposed may have arisen from the disadvantageous method I was forced to adopt in determining my angles. To show that this suggestion is not very probable, I have to state, that I have repeated my measurements on another crystal, and found that the mean of five successive trials, gave 117° 08′ 06″ (the extreme being 117° and 117° 24′.) By the same mode of trial, I found the larger angles of a genuine Heulandite to be 130° 15′, and the angles supposed to be identical with that determined by me for Lincolnite, 113° 38′.

3. *Identity of Fibrolite and Sillimanite.*—I have been led to regard these substances as identical, because in addition to an agreement in hardness and gravity, I had found nothing inconsistent in their crystalline structure. For although no regular form of the first mentioned variety has been found, I have still observed that when a fresh longitudinal fracture of the Carnatic mineral is made, that in a strong light, (aided by a single lens,) there come into view, the same brilliant, micaceous cleavages in the slender individuals composing the mass, as happens in the ordinary Bucholzite varieties of Sillimanite.

4. *Lederite.*—Mr. J. D. Dana remarks in his Mineralogy, (2d edit., p. 422,) that this mineral "is identical in crystallographic as well as other characters, with common sphene," an opinion which is also expressed in the last number of this Journal, p. 350, and again previously, (Vol. xlvi, p. 36.) The mineral in question was removed by me from sphene, on account of its apparent inconsistency in cleavage, with the latter, as well as from its disagreement in angular values with any known crystals of sphene. In my original paper (Vol. xxxix, p. 357) I suggested that should these discrepancies continue to be unaccounted for, and the mineral be allowed a specific character of its own, that I should bespeak for it the name of Lederite. I object to the above method of restoring this substance to its former place, since the difficulty of cleavage still remains where I found it, and that of angles does not appear to me to be satisfactorily smoothed away, by saying that it differs but 1° 22′ in one angle, and 1° 36′ in another, from a figure of sphene contained in Mohs' Mineralogy. Besides it is not true, as asserted in one of the above notices, that my angles were obtained with the common goniometer. I am, however, far from denying that the two substances may yet be shown to coalesce; it is only here maintained, that the uncertainty hanging over the subject is where it was first left.

5. *Goshenite.*—A crystal of this substance, lately obtained by me at the locality, affords a triangular plane on one of the angles, whose inclinations to the adjoining prismatic and terminal faces, are so near to the values of the corresponding angles in beryl, as to remove all probability that these minerals can be shown to be crystallographically distinct.

6. *Microlite.*—The dimensions of the controversy to which this little mineral has already given rise, seem half entitled to place

it under Gigantolite! Mr. AUGUSTUS A. HAYES, in his reëxamination of microlite and pyrochlore, (Vol. XLVI, p. 158,) says that "as Mr. TESCHEMACHER (his colleague in the controversy) has seen nothing in the reply of Prof. S. leading him to doubt the correctness of his statements, he declined noticing the article," while for himself, he shall still adhere to the chemical part of the discussion, and "leave those rules which separate the microlite from pyrochlore, and place it with yttro-tantalite, their full influence." He farther adds, that the absence of yttria, (whose presence was claimed by my research,) is proved by repeating my own experiments, and further observes that my own results do not favor the conclusion I adopted. Fortunately for myself in this delicate conjuncture, where I am not allowed to interpret my own experiments, I have it in my power to bring the opinion of a third person, to whom in a chemical dispute I suppose my antagonist will at least be willing to defer. In his annual report on the progress of chemistry for 1842, Berzelius observes, "In the report for 1835, p. 208, there was a notice of a mineral, found in small quantity with the tantalite of Chesterfield, in North America, and to which the name of microlite was given. This mineral has been made the subject of two researches, (Silliman's American Journal, Vol. XLIV, pp. 33 et 116,) which do not give, as would appear, an exact analysis of it, though they seem to prove that it is nothing more than a yellow yttro-tantalite."

Mr. TESCHEMACHER has, however, so far altered his mind as to come out again with the following notice, which he has published in this country and in England.* "The close examination of above two hundred crystals, of the mineral named microlite by Prof. Shepard, and the comparison of them with about fifty crystals of pyrochlore from the Swedish localities, and from the Ural Mountains, resulting in their agreement in color, cleavage, crystalline form and modifications, indicated to me in 1841 the complete identity of the two minerals, although Wöhler's analysis had decreed the latter to be a titanate, while Shepard's had made the former a columbate of lime.

"This identity, strenuously resisted by Prof. Shepard, although on grounds which show a very superficial knowledge of the whole subject, has been completely proved by subsequent analyses, particularly by that of A. A. HAYES in Silliman's Journal,

* Boston Jour. Nat. Hist., Vol. IV, p. 50, and Lond. Ed. and Dub. Phil. Mag. Vol. XLVIII, No. 1.—Oct.-Dec. 1844. 23

Vol. XXXII, p. 341, and its station as a columbate of lime, according to one of SHEPARD'S analyses, confirmed. DANA'S Mineralogy, one of the arrangements of which is crystallographical, although in the last edition entering into every possible detail on these two minerals, singularly enough omits even an allusion to the above circumstance, notwithstanding its being so remarkable an instance of the power of crystallography, to indicate error in chemical analysis, even in hands like those of Wöhler.

"This mineral is an excellent exemplification of the difficulties which at present surround the natural arrangement of minerals, although chemical analysis is unquestionably hereafter destined to be its basis. The analyses of the dark colored crystals give as ingredients, columbic acid, lime, manganese, iron, tin, lead, uranium, &c.; whereas the minute transparent yellow crystals are probably pure columbate of lime, or perhaps, even obtaining their color from a slight admixture of oxide of uranium, as this color differs much in intensity in crystals of the same size. These small transparent crystals are generally modified on the edges and solid angles of the octahedron; in the large dark colored crystals, these modifications are often nearly obliterared.

"My largest crystal of pyrochlore from the Chesterfield locality is three eighths of an inch at the base of the octohedral pyramid."

We have seen above in remarking upon the labors of Mr. HAYES, that in the opinion of BERZELIUS nothing had been shown which could support the reference here made of microlite to pyrochlore, so far as the chemical evidence might be supposed to weigh. Let us now see what fresh proof from natural properties Mr. T. has adduced. It is all contained in the first sentence of the paper, where he reasserts, that in point of color and crystalline structure the two minerals are the same. But where minerals affect, as in the present case, forms of invariable dimensions, nothing can be shown from structure; which leaves him to fall back upon his first ground, viz. similarity in color, as his sole *point d'appui* in the discussion. Color however proves absolutely nothing as to the identity claimed.

The whole mineralogical question then, if there still be any, comes back to the point where I had left it—viz. to the difference in regard to gravities. Pyrochlore has a gravity=4·20 . . . 4·32. Microlite has a gravity=5·48 . . . 5·646.* As soon as Mr. T.

* A fresh determination on a crystal weighing 4·63 grains, gives 5·646.

with his two hundred crystals (which is a twenty fold greater number than I have had the good fortune to see) shall by simple observation with the balance cause this discrepancy to disappear on the principle of insensible gradation, I shall cheerfully admit that my species vanishes by the same process from a mineralogical existence. But until a spirit of investigation shall stimulate him to this, the only labor which really ever has been demanded, I will suggest that he abstain from the use of all harshness of terms towards those from whom he may happen to differ on scientific points, and at the same time keep in mind that "conceit" as well as "want of industry" are both capable of being displayed in other ways, as well as in that of erroneously propounding new species.

7. *Priority of discovery in the case of Uranite at Chesterfield, Mass.*—It is claimed by Mr. TESCHEMACHER in the Boston Journal, Vol. IV, p. 13, that he is the discoverer of this rare American mineral at the above mentioned locality, and the claim is conceded both in DANA's* and ALGER's† Mineralogy. By a reference to Prof. HITCHCOCK's Report on the Geological Survey of Massachusetts, p. 704, it will be seen that this observation had anteriorly been made by myself. Yours respectfully, C. U. SHEPARD.

New Haven, October 24, 1844.

TO PROFESSOR SHEPARD.

Dear Sir—I have very little to say on the subject of your reply, and that will be said in few words. You state that your treatise "does not claim in any sense whatever" that Danburite, Lederite, Lincolnite, and Washingtonite, are species. These are not numbered as are the others, but the treatise no where states, as far as I can discover, that this variation indicates that the minerals included "are in no sense whatever species;" the reader would infer that they were deemed only of less importance than others. Three of the species were instituted by yourself, and I would respectfully suggest whether there is a propriety in retaining the names of minerals which are of so doubtful character that they cannot be "claimed in any sense whatever to be species."

Chathamite.—If a single crystal of this mineral had been found of a form different from that which *white nickel* is sup-

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* Page 297. † Page 425.

posed to have, (a cube,) I grant that it would establish its specific character, but the "negative evidence" seems to be as much against *Chathamite* as in its favor.

Lincolnite.—In your measurement of Heulandite you suppose M : ĕ to correspond with the lateral angle of Lincolnite instead of T : ĕ, as shown by us in the last volume, p. 416. Taking your new angles of Heulandite as correct, they give us 116° 17′ for the angle T : ĕ, or the prism of Lincolnite. This angle is 1° 5′ nearer your measurement of Lincolnite than that deduced on the page referred to.

Lederite.—In your original description of Lederite, (this Journal, Vol. XXXIX, p. 359,) you state that the limits of variation in the observed angles "were generally within 40′." We find on comparing the angles with one another, reasons however for assuming much larger limits; for example, if the angles P : *a* and M : *a* (see the volume just referred to) are correct, P : M is necessarily 2° too large, as results from the fact that the three angles of a triangle equal 180°, so also if P : *c* and M : *c* are correct, P : M is 1° 10′ too much; and if M : *b* is correct, M : M is 2° out of the way. There is therefore some reason for the allowances that are made in Vol. XLVI of this Journal.

Mr. Dana has handed me some new measurements with the reflective goniometer of the so-called Lederite, made on a small and bright crystal, put into his hands by myself, (from Hammond,) in order if possible to settle the claims of this mineral. The crystal is nearly identical in form with that figured by yourself, except that the smaller planes are too minute for measurement. He obtained, as he informs me, the following angles for M : M, (*r* : *r* of the figure in Vol. XLVI, p. 36,) which are the results of the first five trials, and were obtained without previously acquainting himself with the particular angle of sphene, to which he supposed them to correspond. They are as follows: 113° 26′; 113° 14′; 113° 12′; 113° 28′; 113° 36′.

The mean of these angles gives 113° 23⅓′ for *r* : *r* (M : M) instead of 112° 10′ as stated by you. Now *r* : *r* is given by Phillips (in which it is called d′ on d′) at 113° 24′, and by Mohs at 113° 27′; a coincidence leaving little doubt of the identity with sphene. If the plane *a* in your figure is identical with Phillips' e^2, as seems probable, your angle *a* : *a* is within 40′ of the measurement of Phillips. Yours, &c. B. S. Jr.

Yale College Laboratory, November 12, 1844.

ART. XVIII.—*Abstracts of the Researches of European Chemists;* prepared for this Journal by J. LAWRENCE SMITH, M. D.*

Guano.—From the increased importance that this manure is every day acquiring, many chemists have been induced to undertake analyses of the various kinds; and as the results are of general importance, it is well to give a statement of those recently made. They show a great variety of composition in this substance, and the necessity that the agriculturist is under of having its value properly estimated by a chemist before purchasing, as he may give the same price for two specimens, one of which may be three times as valuable as the other.

MM. Girardin and Bidard (Ann. de Ch. et de Phys. Jan. 1844) find the following ingredients in a South American variety:

Urate of ammonia; oxalate of ammonia; oxalate of potash; oxalate of lime; phosphate of ammonia; phosphate of potash; phosphate of lime; phosphate of magnesia; sulphate of potash, chloride of potassium, and fatty matter—of the three last, very little.

This composition is the same as that of the excrements of aquatic birds and poultry. These authors are inclined to think that the guano is a fossil excrement—the coprolite of some extinct race of birds. Carbonate of ammonia was found in some part of the specimen examined, but it is not a constant ingredient, it being formed by the decomposition of urate of ammonia, which takes place in a moist atmosphere. The nitrogenous compounds of guano being those that fix its value, the quantity present in the above mentioned specimen was estimated and found to be as follows.

Dry uric acid, . . .	18·4,	indicating, . .	6·13	nitrogen.
Ammonia, . . .	13·0,	" . .	10·73	"
In 100 parts of guano, ...			16·86	"

This is a larger proportion of nitrogen than is commonly found; MM. Payen and Boussingault give from 5 to 14 per cent. as the result of their investigations.

E. F. Teschemacher, (Phil. Mag. May, 1844, p. 394,) in an examination of an African variety of guano, found 4 per cent. of humic acid combined with ammonia, with scarcely a trace of uric acid. In

* *Messrs. Editors*—The great interest that it affords me of ascertaining what is going on from day to day in the European school of chemistry, has led me to suppose that many of your readers might be equally interested if they had the means of obtaining the information. I have therefore concluded to give quarterly notices of the most interesting discoveries in chemistry, of which this is the first.

Yours, &c. J. L. S.

Charleston, Nov. 30, 1844.

consequence of this, the soluble part afforded a deep reddish brown solution. It is supposed that this humate of ammonia will act powerfully upon vegetation in addition to the other ingredients, which are those commonly contained in guano. The analysis of the specimen in question gave volatile ammoniacal salts—viz.

Oxalate, phosphate, and humate of ammonia, and organic matter, containing 5 per cent. of ammonia,	25·00
Fixed alkaline salts, consisting of muriate, sulphate, and phosphate of potash,	11·00
Phosphates of lime and magnesia,	32·00
Water,	30·00
Earthy matter,	2·00
	100·00

W. Francis (Chem. Gazette, May, 1844) has also analyzed the African guano, and found 5·50 per cent. of humic acid, and 9·70 of ammonia; 100 parts furnished volatile salts, as

Oxalate, muriate and carbonate of ammonia, combustible organic matter containing 5·50 of humic acid, uric acid, and extractive matter, and 9·70 ammmonia, =	42·59
Water,	27·13
Phosphates of lime and magnesia,	22·39
Residue insoluble in nitric acid, (sand,)	0·81
Alkaline salts, chiefly phosphates and chlorides, with a small quantity of sulphate,	7·08
	100·00

From this analysis the author supposes that the African guano has been subjected more to the decomposing influence of the atmosphere and water than the South American; and in support of this, mentions a remarkable specimen examined by Fritzsche—it was a dry, coarse powder, containing some large compact masses of a yellowish brown color. The compact portion exhibited a stratified appearance, the strata being compressed and undulating. The strata were of two kinds, one of a brownish yellow color, consisting principally of urate of ammonia, the other of a blackish gray or dark brown, being principally clay. Both layers alternated regularly; all the layers of clay have an insoluble white coating of urate of ammonia, which would seem to prove that the guano in question has acquired its present state through the agency of water. Feathers, vertebræ, and fragments of fish-bones occur frequently, as well as remains of plants and seeds. One specimen afforded 37 per cent. of anhydrous uric acid; another with very little argillaceous matter gave 59 per cent. The interposition of argillaceous masses between the urate of ammonia and the

coating of urate of ammonia which adheres so firmly to the seams of the clay, serve to strengthen Mr. Francis in his belief that the guano could not have been deposited by the birds as it now occurs, but that water must have acted some part in the formation of this deposit. In conclusion it is stated that from the existence of so much ready formed ammonia in the African guano, it would be extremely stimulating to vegetation at first, but that its power would soon be lost unless it was previously mixed with something to fix the ammonia, as gypsum or charcoal; on the contrary the species containing the uric acid, from its slow decomposition, would be a constant source of nitrogen proportionate to the growth of the plant.

J. Denham Smith has communicated a very interesting article to the Chemical Society upon the subject of the South American guano. (Chem. Soc. Mem. Vol. II, 140.) All that can be introduced here is a tabular view of his minute analyses.

		1.	2.	3.	4.	5.
Soluble in cold water.	Water,	222·00	215·00	204·20	106·66	77·00
	Muriate of ammonia,	25·50	35·22		4·43	30·30
	Sulphate of potash,	80·00				
	Sulphate of soda,	trace	37·90	259·44	12·23	191·77
	Oxalate of ammonia,	74·00	100·38	93·90		
	Oxalate of soda,					105·63
	Phosphate of ammonia,	63·30	30·06	61·24	trace	
	Phosphate of lime,		12·56			
	Phosphate of potash,		20·02	77·32	14·94	49·47
	Phosphate of soda,		35·82			3·60
	Chloride of potassium,					41·63
	Chloride of sodium,			29·22	9·50	286·31
	Organic matter,	15·00	61·74	6·68	2·40	25·53
Soluble in boiling water.	Urate of ammonia,	154·18	25·12			
	Uric acid,	25·16				
	Phosph. amm. and mag.	5·64	4·04	7·84		1·33
	Phosphate of soda,	1·20	1·28		trace	
	Phosphate of lime,	1·86	2·88		11·37	1·10
	Organic matter,	11·18	6·38	8·60	10·00	7·56
Insoluble in water.	Oxalate of lime,	25·60	107·26	109·58		
	Phosphate of lime,	197·50	192·00	62·70	664·47	131·13
	Phosphate of magnesia,	20·30	19·84	8·74	30·56	25·80
	Humus,	25·36	20·60	8·62	29·73	
	Organic matter,	34·56	11·40			18·36
	Water,		42·42	49·74	80·60	
	Sand, &c.	15·60	16·48	7·20	20·43	4·20
	Oxide iron and alumina,					1·50
	Loss, &c.	0·44	1·50	4·98	2·68	
		1000·00	1000·00	1000·00	1000·00	1002·22

Nos. 1 and 2 were in the state of powder; 3, 4, and 5 were of the concrete variety.

The Combinations of Phosphorus and Hydrogen, by P. THENARD, (Compt. Rend. April, 1844, p. 652.)—In this research the chief thing worthy of notice is the discovery of a new compound of hydrogen and phosphorus, which is liquid at 10° C. (50° Fah.) and spontaneously inflammable in the highest degree. The smallest quantity of it imparts to hydrogen and phosphate of hydrogen not spontaneously inflammable, the property of igniting immediately upon being brought in contact with the air. M. Thenard concludes that the so-called spontaneously inflammable phosphate of hydrogen is not a distinct gas, but the other gaseous phosphate of hydrogen holding in suspense a small quantity of this fluid. It can be obtained by passing the ordinary inflammable phosphate of hydrogen through U tubes kept at 20° below 0° C., (=–2° Fah.) when it will be found to separate itself from the gas in the form of a limpid fluid. Composition $Ph\,H^2$. The discovery of this compound tends to clear up all obscurity connected with the history of phosphuretted hydrogen, and explains the cause of the want of uniformity in the analysis of this gas by various chemists.

Partial Reduction of the Binoxide of Copper by Heat, by FAVRE and MAUMENE, (Compt. Rend. April, 1844.)—The binoxide of copper, when heated to the temperature of melting copper, loses eight tenths of its oxygen, and is transformed into $Cu^5\,O^3$. This points out the necessity of observing some precaution in mineral analysis where the copper is estimated as the binoxide.

Albumen—its Solubility, by A. WURTZ, (Compt. Rend. April, 1844, p. 700.)—It has been generally supposed that albumen owes its solubility in water to alkalies or certain salts present in the fluids generally containing it. Wurtz has proved that perfectly pure albumen is soluble in distilled water; and to procure the substance perfectly pure, he proceeded as follows. The white of eggs mixed with twice its volume of water is passed through a piece of linen to break the cells, to this a little subacetate of lead is added, which determines an abundant precipitate; (care must be taken not to add an excess of the salt of lead, as the precipitate might be redissolved.) The precipitate is washed and suspended in water, through which a current of carbonic acid gas is made to pass. The albuminate of lead is thus decomposed, the albumen being dissolved by the water. The filtered solution still contains a little lead, which may be got rid of by adding a few drops of hydrosulphuric acid, then heating with precaution to 60° C. so as to coagulate a little albumen, which will carry down with it the sulphuret of lead formed. Evaporate at a temperature of 50° C., and the residue will be pure albumen, which has a slight acid reaction, decomposing the carbonate and bicarbonate of soda, with the disengagement of carbonic acid, and the formation of a neutral salt.

Osmium and Iridium—means of obtaining them pure, by FREMY, (Comp. Rend. Jan. 1844, p. 144.)—One hundred parts of the residue of the platinum ore after the platinum has been entirely extracted, is fused with 300 parts of nitre, and kept red hot for an hour; after this calcination it is poured upon a metallic plate, taking care to protect the skin from the vapors of osmic acid. The mass is introduced into a retort and treated with nitric acid, which disengages the osmic acid that is to be condensed in a concentrated solution of potash; that is afterwards to be treated with a little alcohol, which causes the formation of a salt, (osmite of potash,) and its subsequent deposition in the form of a red crystalline powder; the salt can be washed with alcohol. By adding to the osmite a cold solution of sal ammoniac, it is first dissolved, and subsequently decomposed, giving rise to a yellow salt but slightly soluble in water. It is from this that the *pure osmium* is obtained by heating it in a current of hydrogen gas. To obtain the *pure iridium*, the residue left in the retort, after driving off the osmic acid, is first treated with water to wash away the nitre; and the impure oxide of iridium afterwards dissolved in hydrochloric acid. To this solution sal ammoniac is added, which forms an insoluble double salt of iridium and ammonia, as well as a little chloride of osmium and ammonia. This impure salt is suspended in water, and a current of sulphurous acid gas passed through; this dechlorates the iridium salt, rendering it very soluble in water, while the double salt of osmium and ammonia is not altered. This soluble salt of iridium crystallizes in large prisms of a brown color from a solution of sal ammoniac; and by heating them in a current of hydrogen, pure iridium is obtained.

Hydride of Copper, by A. WURTZ, (Compt. Rend. April, 1844, p. 702.)—This is a combination of hydrogen and copper, formed by dissolving 1 part of hypophosphite of baryta in water, precipitating the baryta by sulphuric acid, and adding to the filtered solution 0·8 parts of the sulphate of copper in solution, (concentrated;) the mixture is then gently heated to a temperature not exceeding 70° C. (158° Fah.) and not even that, if hydrogen escapes. It is a yellow powder, presenting the appearance of kermes; in washing it is necessary to do so with water deprived of air, and in an atmosphere of carbonic acid. When dry, it inflames in chlorine; hydrochloric acid acts in a singular manner upon it, decomposing it with the production of a lively effervescence of hydrogen, and the dichloride of copper is formed. This is very remarkable, as hydrochloric acid does not act on copper when alone, and one would presume that it would be less apt to do so when hydrogen was present; but this is another instance of the remarkable decomposition by contact, as in the case of the peroxide of hydrogen, &c. In the

reaction just mentioned, hydrogen escapes from the acid as well as from the hydride. The composition of this body is

$$\left.\begin{array}{ll} \text{Cu,} & 98 \cdot 780, \\ \text{H,} & 1 \cdot 220, \end{array}\right\} \text{corresponding to } Cu^8 H^3.$$

The copper combines with 1200 times its volume of hydrogen.

Transformation of Fibrine in Butyric Acid, by L. Figuier, (Compt. Rend. April, 1844.)—By leaving fibrine in contact with the air during the heat of summer, it liquefies completely at the end of eight days, and the results of the putrefaction are carbonic, acetic, and butyric acids, and ammonia. Butyric acid can also be formed from fibrine by heating it along with potash and lime to the temperature of 160° or 180° C.

On the comparative Composition of Recent and Fossil Bones, by J. Middleton, (Lon. and Ed. Phil. Mag. July, 1844, p. 14.)—The whole drift of this article is to prove that the accumulation of fluorine in fossil bones has been caused by infiltration; it being shown that fluorine exists in the deposits from various waters: as for instance, deposit of a chloride of lime vat; deposit in a water-conduit pipe of a coal mine; stalactitic deposit from the old red sandstone; deposit in a wooden pipe for conducting water from a building; deposit from a kettle used solely for boiling water; deposit from a portion of a vein of sulphate of baryta from the old red sandstone above mentioned; fossil wood from Egypt fossilized by infiltration of carbonate of lime; fossil wood from Egypt fossilized by infiltration of silica. These statements are followed by numerical results of various analyses of fossil bones, most of them containing as much as 11 per cent. of fluoride of calcium. In recent shells there was found 0·79 per cent. of fluoride of calcium. In a fragment of a Greek skull 2000 years old, 5·04 per cent. fluoride of calcium. In the skull of an Egyptian mummy, 2·35 per cent. fluoride of calcium. Skull recovered from the wreck of the Royal George, 1·86 per cent. fluoride of calcium. Recent skull, 1·99 per cent. fluoride of calcium. The skull of a fœtus six and a half months old contains as much as an adult's. The conclusions of Mr. Middleton are, that water drank is the source of fluorine in recent bones, and deposition from water the cause of its *accumulation* in fossil bones. He rejects altogether the hypothesis that the source of fluorine in animals may be their food, but with what justice I cannot see; for if all waters contain fluoride of calcium, and leave this salt in the bony structure of animals using it, most surely it must be left in the fibres of plants that imbibe the same, which being food of animals, may furnish to these latter what it has accumulated from the water.

On the occurrence of Fluorine in recent Bones, by C. Daubeny, (Lon. and Ed. Phil. Mag. 1844, p. 122.)—It would appear that the ex-

istence of fluorine in recent bones has been fully illustrated by this research. The author mentions that the two great difficulties in the way of its detection are the animal matter and carbonates, both of which are to be got rid of before fluorine can be satisfactorily tested for. He therefore began by burning off the animal matter, dissolving the earthy residue in muriatic acid, precipitating the earthy phosphates by ammonia, and testing these last by placing them in a platinum crucible, adding a few drops of sulphuric acid and covering with a piece of glass prepared in the ordinary way with wax.

To separate Zinc from Manganese, by M. Otto, (Journ. de Pharm. et de Chim. Jan. 1844.)—The solution of the two metals containing hydrochlorate of ammonia is rendered slightly alkaline, and then there is added to it hydrosulphuric acid, which precipitates the two metals. To the precipitates acetic acid is added, which dissolves the sulphuret of manganese alone. This property of the sulphuret of manganese can be taken advantage of to separate from all other metals.

Equivalent of Zinc, by P. A. Favre, (Journ. de Pharm. et de Chim. Jan. 1844.)—It was estimated in two ways; first by analyzing the oxalate of zinc. This was done by passing the gaseous products resulting from its decomposition over the oxide of copper, and condensing the carbonic acid thus formed, the weight of which was ascertained, as well as that of the oxide of zinc remaining; from this the equivalent was calculated. The second method was to burn, by means of the oxide of copper, all the hydrogen furnished by the decomposition of water with sulphuric acid, and a known quantity of pure zinc. The water formed by the combustion was collected and weighed. Both methods indicate within a small fraction the same equivalent—33, hydrogen being 1.

Tea—the Composition of, by M. Peligot, (Ann. de Chim. et de Phys. June, 1844, p. 129.)—The principal object in this interesting research was to ascertain the quantity of nitrogen in tea, and to what vegetable principle this nitrogen was due. The quantity of nitrogen found in the various teas was as follows. Pekoë, 6·58 per cent.; gunpowder, 6·60 per cent.; Souchong, 6·15; Assam, 5·10. The quantity is remarkable as being greater than that contained in any vegetable yet analyzed. The teas in their ordinary state were found to lose from 6 to 8 per cent. of water, and when thus dried the part soluble in water averaged from 43 to 47 per cent. The part soluble in water when obtained perfectly dry, afforded 4 to 5 per cent. of nitrogen. The inquiry now arose whether the nitrogen belonged to several principles, or was due to the theine alone. If the proportion of theine said to exist in tea is only ½ per cent. (Mülder) or 1 per cent. (Steinhouse,) it can ac-

count for but a small portion of the nitrogen. Owing to the difficulty of estimating theine quantitatively, M. Peligot supposed that the quantity might be much greater; and in this he was correct, having obtained from 100 parts of gunpowder tea, taken in its ordinary state, 5·84 of theine, equivalent to 6·21 of the same dry; now the watery extract of the tea contained 4·35 of nitrogen, which represented 7·4 of theine; but the theine collected indicated only 3·60 of nitrogen, there remaining 0·75 to be accounted for. Whether this belonged to any other principle it was difficult to say, but the author thinks it probably arose from some ammoniacal salts formed by a decomposition of a small portion of the theine during the treatment with boiling water. The process by which the mass of theine was abstracted is as follows. Add to the infusion of tea while hot, a slight excess of subacetate of lead, then ammonia, boil for some time, filter, wash with care the lead precipitate, treat the filtered solution with hydrosulphuric acid to separate the excess of lead, concentrate the clear solution by a gentle heat, and upon cooling an abundant crystallization of almost pure theine takes place. The mother water by concentration furnishes another portion. To describe the manner in which the last portions were obtained would occupy too much space.

One hundred parts of the tea leaves, after having all the soluble matter extracted from them were found to contain about 4·50 per cent. of nitrogen, due to a substance resembling in its character caseine. The ashes obtained from different kinds of the tea vary from 5·5 to 6 per cent., oxide of iron being a prominent ingredient in them.

Observations on the Green Teas of Commerce, by R. Warrengton, (Chem. Soc. Mem. Vol. II, p. 73.)—There are some important facts contained in this article concerning the adulteration of teas by the Chinese. From almost all green teas a powder can be shaken, exhibiting under the microscope blue and white particles. The blue particles are proved to be prussian blue and the white gypsum. If this powder be washed away by agitating the tea with water, its color becomes changed from a bluish green to a bright lively yellow or brownish yellow tint, and with care it can be re-dried at a temperature below 212° F. without uncurling the leaf or causing it to lose any of its qualities; when completely dry it appears as dark as the ordinary black teas. One cause of the adulteration of this class of teas appears to be the great American demand for this article; and the coarser black teas are cut up and colored with a preparation of prussian blue and gypsum, to give it a green hue. Leaves of other plants are also used by the Chinese to adulterate teas, coloring them in the same way; and it is said that there are spurious teas sent from China not containing a leaf of tea.

Class of double Sulphates containing Soda and a Magnesian Oxide, (Lon. and Ed. Phil. Mag. July, 1844, p. 502.)—These double salts are formed without any difficulty, by dissolving the salts together in equivalent proportions and evaporating at a temperature of 130° F.; below this temperature the sulphate of soda is apt to separate by itself. In this way the double salts of sulphate of soda, with magnesia, zinc, iron, copper, and manganese, have been formed.

Boracic Ether, by M. Ebelman, (Compt. Rend. June, 1844, p. 1202.) —When equal weights of fused boracic acid (pulverized) and absolute alcohol are mixed, considerable heat is disengaged, and upon attempting to drive off the alcohol by heat, it will be found that it is necessary to raise the temperature much above the point of ebullition of alcohol before all the liquid disappears. Stopping the distillation at about 110° C. (230° Fah.) and treating the mass left when cold with anhydrous ether, decanting the ethereal solution, and evaporating by heating progressively up to 200° C. (392° Fah.) there remains a viscid liquid which at this temperature affords white fumes, and solidifies on cooling. This is boracic ether. It has a feeble ethereal odor, and a burning taste; placed upon the skin it produces a sensible impression of heat; subjected to the action of heat, it decomposes at 300° C. (572° Fah.) with the formation of olefiant gas. This mode of the decomposition of boracic ether affords a method of preparing olefiant gas with ease; for by heating together 3 parts of fused boracic acid (pulverized) with one of absolute alcohol, a regular and abundant flow of gas is obtained without the formation of carbonaceous matter. The analysis of boracic ether gives $BO^6\,C^4H^5O$. The action of boracic acid upon pyroligneous spirits is of a similar nature to that it exercises upon alcohol.

The Sulphate of Chrome, by M. E. Kopp, (Compt. Rend. June, 1844, p. 1156.)—The observations made connected with the compound are of some interest; it is composed as already known of $3SO^3\,Cr^2\,O^3$. By adding repeated portions of bichromate of potash to sulphuric acid, heated nearly to the boiling point, it is formed with a disengagement of oxygen gas; the chromate is completely decomposed; and if the mass be treated with water, the excess of acid with the bisulphate of potash is dissolved, but no trace of any chromic salt. And this fact has suggested to the author the possibility of using this as a means of separating chrome from other ingredients; for by heating a mixture of iron, alumina, zinc, chrome, &c. with an excess of sulphuric acid, and concentrating the liquid, the chrome will separate in the form of the insoluble sulphate. It is a green powder; heated it becomes of a rose color, but upon cooling returns to its primitive hue. The action

of a current of hydrogen upon it when heated nearly to redness is extremely curious; it loses all of its oxygen and part of its sulphur, leaving a sulphuret of chrome ($Cr^4 S^3$) of a blackish brown color, having such an affinity for oxygen that it constitutes a very energetic pyrophorus. This sulphuret in contact with chlorine burns with energy; in contact with the vapor of water it is decomposed with a disengagement of hydrogen and hydrosulphuric acid, being transformed into the oxide of chrome.

Solubility of Metals in Persulphate and Perchloride of Iron, by James Napier, (Lon. and Ed. Phil. Mag. May, 1844, p. 365.)—It has been shown in the experiments upon this subject, that silver, tin, lead, antimony, bismuth, cobalt, nickel, and several other metals, were soluble in the neutral persalts of iron, reducing it to a protosalt. The perchloride of iron is proposed as a means of dissolving copper from the surface of silver; the persulphate cannot be used for this purpose, as it attacks readily the silver. Upon the solubility of lead in the persalts of iron, Napier proposes to account for the phenomenon noticed by Mr. West, that when spring-water, which had been running into a lead tank for many years without the slightest action upon the lead, was conveyed through iron pipes to the tanks, the tanks were destroyed in six years. Gold was also experimented with, but the results were doubtful. No double salt is formed in this operation. The solubility of iron in its own persalt, serves to account for the great consumption of iron for the small quantity of copper obtained from the waste water of mines containing the persalt, the copper never being entirely precipitated from the water while any portion of it remains in solution. The iron therefore has to perform a double part—converting the per into the protosalt of iron, and decomposing the salts of copper.

A new series of Double Salts, by J. A. Poumarede, (Compt. Rend. May, 1844, p. 854.)—Numerous combinations have been formed of the sesquioxide of iron and its sulphate, with the protoxides and their sulphates, the composition of the salts being expressed by this general formula, $\frac{1}{6}(Fe^2 O^3 3SO^3) + xO SO^3 + 10HO$. The sulphate of the protoxides and peroxides of iron (sulphate ferroso-ferric) is formed by adding two parts of the sulphate of the protoxide and two parts of the sulphate of the peroxide to five or six of water; after a few moments the liquid becomes warm, and the two dissolve entirely, giving rise to a clear brown solution, which affords upon evaporation crystals of the salt in question. It is soluble in every proportion in water; upon analysis it proves to be a neutral salt, the oxygen of the bases being to that of the acids as 1 to 3. The sulphate of the peroxide of iron can be combined in the same way with the sulphates of zinc and copper,

forming the sulphates zincico-ferric and cuprico-ferric. It is remarkable that these salts behave towards reactives as simple salts of an unknown radical. Alkalies precipitate the oxides in a state of combination, the character of which has no connection with that of the separate oxides acting like a simple oxide. The author very justly remarks, that since we see compound oxides presenting the character of simple oxides, may not some of the oxides we now consider simple be compound, as was proved to be the case with the black oxide of iron, a long while considered the protoxide; the same is true of the oxides of cerium and yttria, which Mosander has shown to contain oxides of lanthanium, dydimium, erbium, and terbium. A general conclusion has been arrived at by this research, which is, that whenever a solution of two oxides, one of which is the sesquioxide of iron, is treâted by an alkali, the precipitate that appears at first is a combination of two oxides; for this to take place it is necessary that the salts should be present in such quantities as that the oxygen of the protoxide should be at least double that of the peroxide.

Action of Ammonia upon Butyric Ether, by G. CHANCEL, (Compt. Rend. May, 1844, p. 949.)—The action of ammonia upon this ether is similar to that it exercises upon oxalic ether; that is to say, it gives rise to a butyramide in the one case, as it does an oxamide in the other; although the action is slower, requiring some eight or ten days to be completed. It is formed by adding together in a phial one part of butyric ether and five or six of ammonia, agitating frequently; upon evaporating two thirds of the fluid, the amide deposits itself in the form of tabular crystals of a pearly lustre, colorless and transparent—does not alter by contact with the air; possesses a sweet and fresh taste, followed by a bitterish after taste in the back of the mouth; melts at 115° C. (239° Fah.) into a colorless liquid which can be volatilized without any residue; soluble in water, alcohol, and ether. The alkalies decompose it in solution at 100° C. (212° Fah.) into ammonia and butyric acid. Composition $C^8 H^7 O^2 AzH^2$.

A new Cyanide of Gold, by JOHN CARTY, (Lon. and Ed. Phil. Mag. Sup. July, 1844, p. 515.)—Protochloride of gold is decomposed by cyanide of potassium, forming a yellow matter perfectly soluble in an excess of the cyanide; to this solution hydrochloric acid in excess is added; and on boiling a bright yellow precipitate is formed, which is the cyanide in question. It is insoluble in water, alcohol, or ether, but soluble in ammonia and cyanide of potassium; decomposed by heat, furnishing cyanogen gas. It is a protocyanide, composed of 200 parts of gold and 26 of cyanogen.

Chlorazotic Acid, by M. BAUDRIMONT, (Journ. de Pharm. et de Chim. Jan. 1844.)—The property that aqua regia has of dissolving gold and platinum, and which has been supposed to be due to the presence of chlorine, is shown to be owing to a peculiar acid, having for its composition $Az\,\overline{O^3Ch^2}$. It can be obtained by mixing together two parts of nitric and three parts of hydrochloric acids of commerce, when it escapes in the form of red fumes, mixed at first with the vapor of a little hydrochloric acid; it can be condensed in a U tube placed in salt and ice, and then appears as a liquid of a deep red color; in this state it attacks all metals when brought in contact with them; with finely divided silver it explodes immediately. In acting on metals it forms a chloride and a nitrate. Its action on metallic oxides indicates that it is an acid of a definite character, being represented by nitric acid, with two atoms of oxygen substituted by two atoms of chlorine.

The Oxides of Gold, Purple of Cassius, and Fulminating Gold, by L. FIGUIER, (Compt. Rend. April, 1844.)—The green powder described by chemists as the protoxide of gold is found to be a mixture of metallic gold with the oxide. This latter, instead of having the extreme instability ordinarily allotted to it, is found to be the most unalterable of all the oxides of this metal. It is a violet powder so dark as to appear black when in a hydrated state. It is an indifferent compound, combining with both bases and acids. The hydracids produce a deposit of gold, dissolving a tritoxide that is formed. With ammonia it forms a violet fulminating compound; at 250° C. (482° Fah.) it is decomposed. The protoxide can be procured in various ways by treating the neutral trichloride of gold with the protonitrate of mercury; by acting upon the tritoxide of gold with acetic or almost any of the organic acids, or with the salts of their acids, vegetable or animal matter produces the same effect. Figuier thinks that he has discovered a compound of gold and oxygen containing more oxygen than any of its oxides previously known—it is called *perauric acid*. Its composition has not yet been made out; it is formed under the following circumstances: when the tritoxide of gold is boiled with caustic potash, there is formed an abundant precipitate of the protoxide of gold, without any escape of oxygen, which must therefore combine with a portion of the tritoxide, forming a compound more highly oxygenated, that remains dissolved in the potash. *The purple of Cassius* when pure is shown to be a neutral stannate of the protoxide of gold; without regard to the manner in which it may be formed, its formula is $3(St\,O^2)\,Au^2\,O+4HO$. The stannic acid has been shown by Fremy to require three equivalents for the formation of the neutral stannates. There is also a bistannate of the protoxide, $6(St\,O^2)\,Au\,O+4HO$. The *fulminating gold* is sup-

posed to be rather a compound of the oxide of gold and ammonia than a nitride of gold, as advanced by Dumas; the principal reason for so thinking, is that there are as many varieties of fulminating gold as their oxides of this metal.

Saccharic Acid, by M. HEINTZ, (Beric. Königl. Preuss. Akad. Jan. 1844.)—He has succeeded in preparing this acid without any difficulty in a state of purity, by treating 1 part of sugar with 3 parts of nitric acid of 1·25 sp. gr. and not heating it higher than 122° F. By attending closely to the temperature no trace of oxalic acid is formed. After the reaction is completed, the mixture is saturated with carbonate of potash, then acetic acid is added until the mass smells of it, when the slightly soluble bisaccharate of potash is left undissolved, and if dried between blotting paper and re-crystallized, it can be obtained perfectly pure; from this the saccharate of cadmium is formed, and decomposed by hydrosulphuric acid to furnish the saccharic acid, (the lead salt will not answer for this purpose.) The acid can be obtained as a brittle mass by evaporation and desiccation in a vacuum with sulphuric acid.

Sulphacetic Acid, by M. MELSENS, (Ann. de Chim. et de Phys. March, 1844, p. 370.)—This acid is formed by the action of sulphuric acid upon acetic acid; the best mode of forming it is as follows. Add together anhydrous sulphuric and acetic acids, and assist the reaction by heat; saturate with carbonate of baryta; decompose the crude salt with sulphuric acid; filter; saturate with oxide of silver, when the sulphacetate of silver will crystallize out. The acid can now be obtained by decomposing this salt with sulphuretted hydrogen. The acid can be procured in the form of crystals which are very deliquescent; heated to 160° C. (320° F.) it gives the characteristic smell of caramel or burnt tartaric acid, when it becomes brown; at 200° C. (392° F.) its decomposition is complete. The following formula represents the composition of the acid. $C^8(H^2, SO^2)O^3, SO^3, 2HO+2Aq$. It combines with bases, 2HO being replaced by two atoms of the base.

Lithia—Blowpipe test when mixed with Soda, by W. STEIN, (Journ. für Prakt. Chem. Vol. 31, p. 361.)—The method proposed is to fuse the mixed salts upon a wire; immerse it while still warm into the tallow of the candle used; introduce it again in the flame, and watch closely the flame, when, if lithia be present, it will have a red margin. The reason of this appears to be, that the lithia salts are volatile at a lower temperature than the soda salts, which latter will therefore not conceal the effect of the lithia, provided the blowpipe be not used, and the temperature not elevated sufficiently to volatilize the soda; for if that be done, the minutest portion will render the blowpipe test for lithia useless.

New Salts formed by the Action of Sulphurous and Nitrous Acids upon the Alkaline Bases, by E. Fremy, (Compt. Rend. June, 1844, p. 1110.)—If a current of sulphurous and nitrous acids be made to pass into a solution containing a considerable quantity of potash, there is immediately deposited long silky crystals of a salt of potash almost insoluble in cold water; the salt contains a new acid composed of sulphur, oxygen, and nitrogen. Heat decomposes this salt in a characteristic manner, by transforming it into sulphate of potash, ammonia, and a volatile ammoniacal salt. The salts of soda and ammonia are formed in the same way—they are soluble in cold water. These solutions when cold are neutral, and are not affected by the salts of baryta or lead; but if boiled they become strongly acid, from the formation of sulphuric acid, and a salt of ammonia is at the same time produced.

Art. XIX.—*Bibliographical Notices.*

1. *On Dinornis, an extinct Genus of tridactyle Struthious Birds, with descriptions of portions of the skeletons of six species, which formerly existed in New Zealand.* By Professor Owen, M. D., F. R. S., Z. S., &c. &c. (Part I.)—In this paper of Prof. Owen, which forms about forty pages quarto of the Transactions of the London Zoological Society, with fifteen plates, we have an account of one of the most important zoological discoveries of the present century; nor is it scarcely less interesting to geology. As our notice of the paper must necessarily be brief, we shall direct the attention of our readers to the most interesting points contained in it.

(1.) *The history of the discovery.*—Portions of this history have already appeared in several places upon the pages of this Journal. We need here, therefore, give only a condensed summary.

Several years ago, Prof. Owen received from New Zealand the single shaft of a femur, six inches long, with both extremities broken off. It did not present the characters of a true fossil, and yet appeared to have been on or in the ground for some time. From an examination of it, Prof. Owen came to the conclusion, that it belonged to a Struthious bird, which was a "heavier and more sluggish species than the Ostrich." This interpretation of this bone was published in the Transactions of the Zoological Society, Vol. III, p. 32, and in the Proceedings of that Society for November, 1839; and on this evidence alone, he there declared himself willing to risk his scientific reputation upon the statement that "there has existed, if there does not now exist in New Zealand, a Struthious bird, nearly, if not quite equal in size to the Ostrich." In

1842 a letter was received from Rev. Wm. Cotton of New Zealand, confirming this announcement; and in the same year another letter was addressed to Rev. Dr. Buckland from "Rev. Wm. Williams, a zealous and successful church missionary" in New Zealand, dated Poverty Bay, Feb. 28th, 1842, containing a full account of the discovery of the bones, accompanied by specimens. These, with a second bone, and three specimens from Dr. Richardson, were put into the hands of Prof. Owen, and enabled him not only to confirm his first opinion, but to describe in the present paper, five distinct species of Dinornis, "ascending respectively from the size of the great Bustard to that of the Dodo, of the Emeu, of the Ostrich, and finally attaining a stature far surpassing that of the once deemed most gigantic of birds." The total number of bones received was forty-seven, dug out from the beds and banks of fresh-water rivers, always in alluvium. Yet the bird had not been in existence within the memory of any of the inhabitants, although Mr. Williams gives a story from an American and two English sailors, that they had been out hunting this bird, which was from fourteen to sixteen feet high; but which they did not fire at through fear. The name given by the natives to the animal to which these bones belonged, was *Moa*.

From these bones Prof. Owen has made out five species satisfactorily, and one (the *D. ingens*) "provisionally." Their names and the proximate height of each are as follows.

Dinornis	giganteus,	height at least		10	feet.
"	ingens,	"	"	9	"
"	struthoides,	"	"	7	"
"	dromœoides,	"	"	5	"
"	didiformis,	"	"	4	"
"	otidiformis,	size of the great bustard.			

Prof. Owen is of opinion that these birds are now extinct in New Zealand; but the chemical constitution of the bones shows that they must have formed a part of living animals at no very remote period; for they contain just about as much animal matter (38 per cent.) as the bones of the living Ostrich. He thinks it probable that their extinction was the result of the persecutions of men; for since, according to Mr. Darwin, the whole of New Zealand, more than seven hundred miles long and ninety miles broad, does not contain, with the exception of a small rat, a single indigenous mammiferous animal, these birds would be hunted constantly for food, and their great size would make them an easy prey. Mr. Owen, with great probability, suggests that "when the source of animal food from terrestrial species, was reduced by the total extirpation of the genus Dinornis, to this low point, then may have arisen those cannibal practices, which, until lately, formed the oppro-

brium of a race of men in all other respects much superior to the Papuan aborigines of the neighboring continent of Australia, and very little inferior to the Polynesian natives of the most favored islands of the Pacific."

In Volume XLVII, of this Journal, (page 313,) we have suggested whether the enormous nests described by Cook and Flinders on the coast of New Holland, did not indicate the existence at present of the Dinornis. It will be seen in the present number of the Journal (p. 61) that Prof. Owen does not fall in with such an opinion, and certainly for strong reasons. We have another fact to state, bearing upon the same point; not wishing, however, to express an opinion how far it renders probable the present existence of a species of Dinornis. Prof. Silliman has just put into our hands "Jacobs' Scenes, Incidents, and Adventures in the Pacific Ocean," &c., recently published; referring us to a description in that work, of "*a Doondoo hunt*" on the island of New Britain, or *Bidera* as Jacobs calls it, which lies near Papua, or New Guinea, in about five degrees south latitude. In company with a hundred native warriors, all completely armed for battle, Mr. Jacobs marched towards the interior of the island for two days, and encamped amid the high grass on an elevated plain. "At the break of day," says he, (p. 267,) "I started up, perfectly bewildered at hearing all the warriors shout at the top of their voices, 'Doondoo! Doondoo!' while at the same time they seized their spears and clubs and jumped to their feet. I picked up my rifle and did the same. Two ferocious and monstrous looking birds resembling the Ostrich, ran past us like race-horses, with heads six feet above the ground, and apparently powerful enough to knock down a man." The warriors threw their spears and clubs, and one of them fired a musket in vain; but the rifle of Jacobs brought one of them to the ground. "We soon surrounded the Doondoo," says he; "he was a majestic bird, of a species between that of the Cassowary and Ostrich. His head and beak were covered with a ribbed horny excrescence, or coat of mail, that looked truly formidable, more especially when mounted high in the air as the bird was running. His legs were remarkably powerful, and the fleetness of these birds is so great that the natives never attempt to pursue them. The natives find it difficult to capture or kill the Doondoo, more especially when they attempt to interfere with, or molest their nests, or young; at these times they become perfectly furious, and have been known to knock down natives and kick them to death. The feathers, the beak, and the quills of the Doondoo are considered of great value in Bidera. The first are worn upon the heads of the chiefs, the second upon the breast, as an amulet, and the latter pass for money; so that for a certain number you can buy any maiden for a wife that you fancy. So difficult do the Carwa-

rians find it to capture this valuable bird, that if they succeed in killing one every year, they consider themselves amply compensated for the fatigues of a march to the Doondoo plains."

The party soon fell in with four more Doondoos, two of which were killed by the fire-arms, and in consequence of his great skill, the next day Mr. Jacobs was crowned by the chiefs and army of Carwary, and decorated with the plumes and beak of the bird.

Mr. Jacobs makes no pretensions to being a naturalist. But if the preceding statements can be depended upon, is not the probability strong that we have here an account at least of an undescribed species of Struthionidæ, if not a species of Dinornis? Unless indeed, it be the Cassowary, which we know to be crested. But from that species Mr. Jacobs expressly distinguishes the Doondoo.

(2.) *This paper of Professor Owen affords us some beautiful and instructive examples of the wonderful principle of correlation of structure in animals.*—Cuvier maintains that "a single bone, or articular facet of a bone," would often enable the comparative anatomist to reconstruct the whole animal, so mathematical are the relations between the bones. But his successor, M. De Blainville, has endeavored to depreciate and throw doubt over this principle, in his "Osteographie." Prof. Owen agrees with Cuvier, and the Dinornis has afforded him a triumphant example of the truth of the principle. For at first he had only the shaft of a femur, six inches long, from which to determine the character and size of the animal. He found "a coarse cancellated structure continued through the whole longitudinal extent of the fragment." And he adds, "there is no bone of a similar size, which presents a cancellous structure so closely resembling that of the present bone, as does the femur of the Ostrich; but this structure is interrupted in the Ostrich at the middle of the shaft where the parietes of the medullary, or rather air cavity, are smooth and unbroken. From this difference I conclude the Struthious bird indicated by the present fragment, to have *been a heavier and more sluggish species than the Ostrich;* its femur and probably its whole leg was shorter and thicker." And on such reasoning, which intelligent men unacquainted with comparative anatomy would certainly pronounce to be mere *moonshine*, does the author add, as already quoted, "So far as my skill in interpreting an osseous fragment may be credited, I am willing to risk the reputation for it on the statement, that there has existed, if there does not now exist, in New Zealand, a Struthious bird nearly, if not quite, equal in size to the Ostrich."

These statements the author published in 1839; and now, if the skeleton of such a bird should have been afterwards found in New Zealand, what better proof could we have that the principle of corre-

lation, sagaciously seized upon by Prof. Owen, must be when rightly interpreted, almost as sure as mathematics. The skeleton or a large part of it was found, and is figured in this memoir of the natural size, and it corresponds almost exactly (for the broken femur belonged to *D. struthoides*, which was about the size of the ostrich) to the predictions of the Professor.

In calling the Dinornis a Struthious bird, the author had in fact made it essentially apterous, or wingless, since this is a general character of the family. But says Prof. O., " it has appeared strange and almost incredible to some, that the cancellous texture of the shaft of a thigh bone should give, to speak mathematically, the presence or absence of wings. But if the negative had been premature and unfounded, a guess rather than a demonstration, its fallacy might have been exposed by the very next bone of a Dinornis transmitted from New Zealand. A bird of flight has as many wings as legs: it has two humeri as well as two femora, two radii as well as two tibiæ, two ulnæ as well as two fibulæ; the humerus and radius are usually, and the ulna is always longer and larger than their analogues in the hind extremities; then also there are the two distinct carpal bones, a metacarpus and characteristically modified phalanges. The chances were thus greater, that the next bone of an extremity discovered in the alluvium of New Zealand would have been one of the anterior members, had these been developed to serve as wings in the Dinornis. But what is the fact? Eighteen femora, eleven tibiæ, and six tarso-metatarsi, with two toe phalanges, have been consecutively discovered, and not a trace of any part of the osseous frame-work of a wing; not a fragment of scapula, of humerus, or of the bones of the fore-arm or hand."

In all apterous birds the rudiments of wings remain. In the Apteryx, careful dissection alone can discover them. They are never developed in the Emeu; and " from the known relations of the development of the air-cells to that of the anterior members in existing Struthionidæ," the author infers that " the wings were more rudimentary in the Dinornis than in the Emeu, but not quite so minute in proportion to the body as in the Apteryx." Curious logic this, to one ignorant of comparative anatomy. But we doubt not it will prove to be infallible.

From a minute examination of the forty seven bones sent from New Zealand, and a sagacious application of the fruitful law of correlation, the author is led, first, to distinguish the Dinornis from all the living Struthionidæ; and secondly, to make out five or six species of the genus. The tarso-metatarsal bone of the Dinornis distinguishes it in one way or another from all the living Struthionidæ; but only a skillful anatomist would have been able to make out all the differences. The specific characters are derived, not merely nor chiefly from a difference

of size, but from a difference of proportion in the measurements of different parts. Thus the *Dinornis didiformis* differs from the *D. giganteus* " in its relatively shorter and broader metatarsus." But we cannot enter into the details of this part of the memoir, which would be scarcely intelligible without the splendid plates by which it is illustrated. Yet it forms the part that must have required the greatest labor and most profound anatomical knowledge, and it constitutes a most instructive and valuable lesson to him who aspires to an acquaintance with the noble science of comparative anatomy. We do not recollect any problem in the " Ossemens Fossiles," that required equal sagacity and skill to solve.

(3.) *This paper throws light on the Ornithichnites, or fossil footmarks of birds in the new red sandstone of this country.*—" In 1836," says the author, " Prof. Hitchcock published his remarkable discovery of impressions in the new red sandstone of the valley of the river Connecticut, Massachusetts, which he conceived to be the footprints of birds, the largest belonging to a species with three toes, surpassing the Ostrich in size. The epoch of these impressions is as ancient as that of the Cheirotheria or Labyrinthodont footsteps in Europe, and more ancient than those of the oolite and lias, from which the remains of our most extraordinary extinct reptiles have been obtained; but no fossil bones of birds have been found associated with the Labyrinthodont and Thecodont reptiles, nor with those of the lias or oolites, the Pterodactyles of which were once mistaken for birds. The Wealden is the oldest formation in which true ornitholites have hitherto been discovered. The ancient footprints of the Connecticut sandstones were for the most part supposed to be those of Grallæ; but the high geological antiquity, and the inferences which might be deduced from the low character of the air-breathing animal creation as indicated by fossil bones, of the condition of the atmosphere during the deposition of the oolites, lias, and new red sandstones, led me to express a doubt in my report on British Fossil Reptiles, whether footprints alone were adequate to support the inference, that the animals that impressed them actually possessed the highly developed respiratory organization of a bird of flight. One could hardly in fact venture to reconstruct in imagination the stupendous bird, which, on Dr. Hitchcock's hypothesis, must have left the impressions called *Ornithichnites giganteus;* for before 1843, the only described relic of the extinct New Zealand bird did not warrant the supposition of a species larger than the Ostrich."

" The species of Dinornis, in fact, to which that relic belonged, we know not to have exceeded seven feet in height, which is the average stature of the Ostrich. But the bones of the *Dinornis giganteus*, subsequently acquired, demonstrate the existence at a comparatively recent

period, of a bird whose tridactyle footprints, as will be presently shown, surpassed the *Ornithichnites giganteus* of Prof. Hitchcock."

By comparing the *Ornithichnites giganteus* with the track and foot of the Ostrich, Prof. Owen concludes that "the breadth of the distal end of the tarso-metatarsal bone of the tridactyle bird that impressed the *Ornithichnites giganteus*, must have been three inches nine lines. But the breadth of the distal end of the tarso-metatarsus of the *Dinornis giganteus*, is five inches. According, therefore, to the proportions of the *Ornithichnites giganteus*, the breadth of the hind part of the footprint of the *Dinornis giganteus* must have been six inches, and its length twenty one inches and a half."

Prof. Owen can judge much better than we can, whether it is quite safe to infer the breadth of the distal extremity of the tarso-metatarsus of a tridactyle bird, from that of a didactyle bird. But admitting the rule, we remark farther, that his measurements of the *Ornithichnites giganteus* were taken, as we suppose, from a cast in the Hunterian Museum, London, of the same size as the specimen figured in this Journal for January, 1836. That was indeed a very safe specimen from which to infer the size. But we have long been acquainted with tracks of this species considerably larger, a description of some of which is given in the present number of this Journal, (p. 63.) Yet even these (from eighteen to twenty inches long) fall short of the foot of *Dinornis giganteus* as calculated by Prof. Owen. He thinks that the *Dinornis struthoides*, the third species in size, might have made a track as large as the specimen of *Ornithichnites giganteus* to which he refers, and that the "footprint of the *Dinornis didiformis* was probably about the size of the *Ornithichnites tuberosus* of Prof. Hitchcock."

"From the foregoing comparison of the bones of the feet in the different species of Dinornis with the impressions left by the ancient birds of the American continent," continues Prof. Owen, "it must not, however, be concluded that these were species of Dinornis. Agreement in the size of the foot and number of the toes does not constitute specific or even generic identity in ornithology, as the living Emeu, Rhea, and Cassowary testify; and though we may admit that the discovery of tridactyle terrestrial birds of a size more gigantic even than that indicated by the *Ornithichnites giganteus* and *Ornithichnites ingens* tends greatly to remove the skepticism with which such evidences of the extinct animals of the Triassic period had been previously received, yet the recognized succession of varying vertebrated forms in the interval between that period and the present, forbids the supposition that the same species or genus of birds could have maintained its existence throughout the several great changes which the earth's surface has undergone during that vast lapse of time."

We well remember how disheartening was the effect upon our mind of Professor Owen's opinion, above alluded to, adverse to the ornithic character of the footmarks of New England. The man whom we considered as better qualified to judge on such a point than any one in Europe, had decided against us, and for reasons which were certainly most weighty, viz. the enormous size of the tracks and the improbability that animals of so high an organization as birds existed so early. True, eminent men were with us, and we could not give up our opinion; but we trembled for it, and greatly feared that we should not live to see it established—for we could not derive from ichnology or any other part of geology any answer to these objections, particularly the last. Little did we imagine that light would come from the distant island of New Zealand, and as an incidental result of missionary labors. But that part of the world seems to be a sort of Atlantis still left above the waters, while the rest of the ancient earth has gone down beneath them, and save so far as geology has restored it, into the depths of oblivion; but the peculiar Fauna and Flora of Australasia form the connecting link between the present and past economies of organic existence. A single fragment of bone from that region, touched by the magic wand of comparative anatomy, not only brings before us the Dinornis of more recent times, but almost restores those congeneric races that far, very far back in the world's history, trod the shores of estuaries almost antipodal to New Zealand. Truly distance either in time or space is nothing in nature; and the correlation of animal structures, so beautifully developed by Cuvier, Owen, and others, is but a specific example of the great law of harmony, that links together by a golden chain the great and the small, the past, the present, and the future, throughout the universe.* H.

2. *Ehrenberg's Observations on the Fossil Infusoria of Virginia and Maryland, and comparison of the same with those found in the Chalk Formations of Europe and Africa.*—In the monthly report for February, 1844, of the Berlin Academy of Sciences, we find a notice of a memoir by Ehrenberg, giving the results of his examination of specimens of fossil infusoria, received by him through Prof. Bailey, from the localities discovered by Prof. W. B. Rogers at Piscataway, Maryland, and by Mr. Tuomey at Petersburg, Virginia, together with a comparison of the

* A portion of the skull of Moa has been sent to England from New Zealand. The beaks unfortunately are wanting; the conformation of the head resembles that of the Dodo, and from the large development of the olfactory nerves, Mr. Owen with much probability supposes its habits resembled those of the Apteryx; but that its wings were less rudimentary.—*Extract from a private letter from Dr. Mantell to the Editors, Dec.* 2, 1844.

American forms with those found in the chalk formations of Europe and Africa. The principal object of this memoir is to present in a tabular form the names of the species found in the American tertiary deposits, and of those detected in the chalk marls of Oran in Africa, Caltasinetta in Sicily, and Egina in Greece. The tables also indicate which species are still living, and therefore show the relations of the present world with the tertiary and succeeding epochs. The full description of the new genera and species is to be given in a forthcoming volume. Among the interesting results of this examination presented by Ehrenberg are the following.

1st. The remarkable difference which is shown by the American deposits of marine infusoria from those of Oran, Caltasinetta, &c. in the total absence of the calcareous shelled Polythalamia. The siliceous and calcareous shelled animalcules occur together in great numbers both in the present seas and in the chalk marls of Europe and Asia, but no Polythalamia have yet been found in any of the specimens of American infusoria examined by Ehrenberg,* from which he was at first incorrectly led to suppose that the specimens had been treated with acids to remove the calcareous matter. Ehrenberg remarks that these marine deposits of exclusively siliceous animalcules are not however without analogy, as is shown by the formation of all writing chalk from calcareous animalcules alone, and by the existence of many fresh-water deposits of purely siliceous infusoria.

2d. The comparison of the forms from Richmond, Petersburg, and Piscataway, proves that the infusorial mass at Richmond is composed of at least 112 species, that of Petersburg of 67, and that of Piscataway, Maryland, of 67 also.

3d. The two deposits of Virginia have about 46 species in common out of 130, or about one third; Richmond has 66 species which have not been found at Petersburg, and Petersburg 18 not yet found at Richmond. Both of the localities in Virginia agree with that in Piscataway, Md. in 46 species out of 155, or about two sevenths. In Virginia are found 84 species not detected in Maryland, and in Maryland 21 not found in Virginia.

4th. Of the 155 North American forms, 60 (52 Polygastrica, 8 Phytolitharia) agree with those which occur as fossils at Oran, Sicily, and Egi-

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* No Polythalamia have been found in any of the infusorial matters which we have examined from as many as twenty localities in Virginia and Maryland; but as they abound in other beds of the eocene and miocene tertiary, it cannot be supposed that they did not also exist during the deposits of the infusorial beds. It appears probable that chemical changes have destroyed the minute calcareous shells without affecting the siliceous ones. That such changes have taken place is shown by the fact that in all the specimens of the infusorial beds which we have seen, *casts* alone of the shells of the large mollusks are preserved.

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na, and 30 (27 Polygastrica, 3 Phytolitharia) are identical with those which at Caltasinetta undoubtedly belong to the chalk formation.*

5th. It appears that the exclusively American genera do not, as was at first supposed, present only single species. The genus Goniothecium has now 7 species, Rhizosolenia 2, and 4 species of a new genus, Dicladia, have been detected.

6th. The number of genera not yet found any where but in America has been increased by this examination from 6 to 11, and it is probable that the *Triceratium spinosum* of Bailey will form a twelfth, which may be called Tetrachæta, and which differs from Triceratium as Denticella does from Biddulphia, but has 4 instead of 2 lateral spines.

From Ehrenberg's account of the new American genera we have selected the following as presenting the distinguishing characters of some of the most interesting siliceous shelled Polygastrica.

The four genera Asterolampra, Eupodiscus, Aulacodiscus, and Symbolophora, belong to the family of Naviculæ, and resemble Coscinodiscus in their orbicular form and by not forming chains. They are distinguished as follows:

1. Asterolampra. Divided in the central portion alone into imperfect cells by slender septæ, which do not reach the margin, alternating with radii which reach the margin and which are not supported by septæ.

One very elegant species, *A. Marylandica,* with 8 marginal radii, occurs at Piscataway, Md.

2. Eupodiscus. Having tubular processes with perforated apices near the margin of both sides. The name Eupodiscus is now substituted for the old name Tripodiscus, which is rejected as inappropriate, as Ehrenberg has by his own observations confirmed our statement that the number of processes may be greater than three. The species with 6 projections is called *Eupodiscus Rogersii* by Ehrenberg, while the one with seven is called *E. Baileyi.* We still think that the number of the processes will prove to be variable even in the same species.

3. Aulacodiscus. Having (instead of the tubular pediform processes of Eupodiscus) clefts radiating from the centre to tubercles near the margin, and with the surface granular, not cellular. One species, *A. crux,* is found fossil at Richmond.

4. Symbolophora. Having the septæ and cells radiating from a solid angular centre; surface not cellular. The only species, *S. Trinitatis,* from Piscataway, is a very remarkable and elegant form.

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* As Ehrenberg in his tables indicates a doubt as to the tertiary character of our infusorial deposits, it is proper to state for the information of those not familiar with American geology, that the infusorial strata of Maryland and Virginia are certainly of the epoch of the miocene tertiary, as is shown by their containing casts of miocene fossils and by their having strata of numerous and well preserved miocene fossils both *below* and *above* them. J. W. B.

5. Rhaphoneis. Has not the orbicular form of those just described, but is quadrangular, navicula-like, not forming chains, and having neither the ribs, lateral aperture, or umbilicus of Navicula, but with the sides marked in the middle with a longitudinal suture. Six species are described, among which we recognize several forms which are quite common in the fossil infusoria of Virginia and Maryland, as well as in the living state upon our sea-coast.

6. Dicladia. This genus is doubtfully referred to the Bacillaria. It has the lorica, simple bivalve, siliceous, one-celled, not forming chains, valves unequal; one turgid simple, the other with two horns which are sometimes branched. This genus includes the curious forms of unknown origin which we have represented in Plate III, figs. 24 to 27, Vol. xlvi, of this Journal.

Besides the account of the new genera, Ehrenberg also gives in his memoir the characters of 140 new species of microscopic Polygastrica, Polythalamia, and Phytolitharia, more detailed accounts of which will be given in his forthcoming volume, a work which will be eagerly sought for by all lovers of this fascinating branch of paleontology.

It may be interesting to add to the above, that in a letter recently received from Ehrenberg he gives us the following authentic names of several of the forms represented in Plate III, Vol. xlvi, of this Journal.

Figs.	Bailey.		Ehrenberg.
1, 2,	Podiscus Rogersi	=	Eupodiscus Rogersii.
3 to 9,	Zygoceros (Biddulphia) Tuomeyi	=	Denticella tridentata.
10, 11,	Zygoceros rhombus	=	Denticella rhombus.
13, 15,	Navicula concentrica	=	Goniothecium Rogersii.
24, 27,	Bodies of unknown nature	=	Dicladia.
29, 30,	" " "	=	Rhizosolenia.
21,	Bodies with large cells	=	Lithocampe radicula.

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3. *The Botany of the Antarctic Voyage of H. M. discovery ships Erebus and Terror, in the years* 1839—1843, *under the command of Capt. Sir James Clark Ross, Kt., R. N., etc.* By Joseph Dalton Hooker, M. D., R. N., F. L. S., Assistant Surgeon of the Erebus, and Botanist of the Expedition. London. Parts 1—3. 1844. pp. 48, 4to. plates 1—25.—The publication of the scientific results of Capt. Ross's voyage, was promptly commenced, and is prosecuted with great vigor. The botanical portion, with which Dr. J. D. Hooker, the botanist of the expedition, is now assiduously occupied, is to appear in monthly parts, until the whole is completed in five volumes royal quarto, with five hundred lithographic plates. It is to be divided into three separate portions, viz. 1st. The *Flora Antarctica*, which is intended to embrace a complete history of the vegetation, as far as known, of the

antarctic regions, viz. of what little of land there is between the parallels of 50° and 78° south latitude, the utmost limit that has been attained by navigators. This is to be executed in the form of separate floras of different groups of islands, &c. The fasciculi that have now reached us are occupied with the botany of Lord Auckland and Campbell's Islands. Thanks to the liberal spirit of interchange that now prevails, and the disposition to further such arduous undertakings by the communication of collections to those who are likely to render them most subservient to the general interests of science, Dr. Hooker has now before him sets of nearly all the extant materials for illustrating the antarctic Flora, consisting not only of his own extensive collections made during three years almost entirely spent in high southern latitudes, but also of the still unpublished herbaria formed by Sir Joseph Banks, Forster, and Solander, in Cook's voyage, that of Menzies, in Vancouver's voyage, the plants obtained in Capt. Fitzroy's voyage, as well as full sets of those collected by the rival French expedition under D'Urville, and in former national voyages; all of which have, with a praiseworthy spirit, been placed in his hands by the proper authorities. With these rich materials, and with the command of the two best botanical libraries (taken together) in the world—that of his father, and that of the British Museum—Dr. Hooker will produce a Flora of the south circumpolar regions of infinitely more importance and advantage to science, than if all these scattered collections were independently published. It were very desirable, therefore, that the *antarctic* plants of the American exploring expedition (by no means, we suppose, the most extensive part of that collection) should also be represented in this general antarctic Flora, by an interchange of specimens, which would doubtless bring in return a full suite of the British collections for the herbarium at Washington. We know not what arrangements are making for their publication; but we speak advisedly when we say that the antarctic botanical collections cannot be creditably elaborated in this country, until the British and French works now in course of rapid publication are completed. When that is done, the work will be easy, indeed; but little of novelty will remain.

The second division of the Botany of Capt. Ross's voyage, will consist of a *Flora Novæ Zealandiæ;* the third, of a *Flora Tasmanica;* or the Botany of Van Diemen's Island. The latter will be indeed an herculean task; and we presume will not be commenced until the other parts are completed. A. Gr.

4. *Species Filicum; being Descriptions of all known Ferns: illustrated with plates.* By Sir Wm. J. Hooker, LL. D., etc. Part I. and II. London, 1844. 8vo.—Sir Wm. J. Hooker commenced his distin-

guished botanical career with the humble but beautiful family of Mosses. But his pen and pencil have since largely illustrated every class of plants; and among them, the graceful tribe of Ferns have from time to time received particular attention. To this the splendid *Icones Filicum*, published by Dr. Greville and himself, and the recent *Genera Filicum*, illustrated by Mr. Bauer's drawings, bear abundant testimony. The present work, of which only two parts have reached us, (although others have probably appeared ere this,) is intended to comprise a systematic account of all the known species, with the chief synonymy, and general descriptive remarks; the whole written in the English language, and illustrated with figures of numerous species which have not previously been represented. The work will be embraced, we suppose, within the limits of a single thick octavo volume. The forty plates given with the two parts already published, contain delineations of about one hundred and fifty species. The text, thus far, embraces the Gleicheniaceæ, and of Polypodiaceæ, the tribes Cyathaceæ and Dicksonieæ. The second part is chiefly occupied with the genera Hymenophyllum and Trichomanes. A. Gr.

5. *Leçons Elémentaires de Botanique, fondées sur l'analyse de 50 plantes Vulgaires, et formant un Traité Complet d'Organographie et de Physiologie Végétale, a l'usage des Etudiants et des Gens du Monde;* par M. Emm. le Maout, D. M., etc. Paris, 1844. Fortin, Masson & cie. 2 vols. 8vo.—We have directed the attention of our botanical readers to several new introductory works on that science, of high excellence, which have recently appeared on the other side of the Atlantic, and especially in Germany and France. It is only in the last volume of this Journal that we gave a concluding notice of Prof. Adrien de Jussieu's admirable volume, specially commending it to all lovers of botany among us who are familiar with the French language. The learned author has since informed us that his work is already passing to a second edition. It augurs favorably for the prospects and popular diffusion of science, that the task of preparing elementary books is falling more and more into the hands of the most eminent naturalists. This is as it should be. By giving this direction to a portion of their useful labors, such men as Jussieu, Endlicher, and Milne Edwards, are performing as important service in the general diffusion of sound knowledge of the sciences they cultivate, as their profound researches contribute to the direct advancement of these sciences. Those most profoundly versed in any scientific subject are best fitted to write popular treatises upon it; while those who know little of it, are least of all qualified to communicate that little to others. Dr. Maout, however, appears to be very well acquainted with the subject he undertakes to

teach, and has produced an excellent work, of a very elementary and popular character, well adapted to the end in view. It is not a full systematic treatise, like that of Jussieu; but is formed on the model of Rousseau's Letters upon Botany, and is intended to occupy the same place as Lindley's Ladies' Botany in England. The author first gives a series of figures of fifty common plants, the representatives of as many different natural orders. These are executed in wood, of the size of life for the most part, colored after nature, and accompanied with brief popular descriptions. Then follows a familiar analysis of their flowers, and a series of particular studies of each plant, so managed as to introduce in succession all the leading facts and doctrines of structural and morphological botany. The seed, the inflorescence, the elementary structure of plants, their physiology, and the general principles of classification are afterwards more systematically considered in separate chapters. The text is copiously illustrated with wood cuts, some seven hundred in number, executed in the very best style of the day, from drawings which, as the best guaranty of their scientific accuracy and artistic excellence, we need only mention were furnished by M. Decaisne, of the *Jardin des Plantes*, who is one of the ablest botanists in France. The paper and typography of the volumes are truly beautiful. The price is fifteen francs, or twenty five francs for those copies which have the atlas colored. A. Gr.

6. *Systema Materiæ Medicæ Vegetabilis Brasiliensis;* composuit Car. Fred. Phil. de Martius. (Leipsic, 1843. pp. 155, 8vo.)—This little treatise is one of a long series of very interesting works on the natural history of Brazil, with which Prof. Von Martius has been occupied since his return from his scientific visit to that country. Among the fruits of that journey are the splendid *Genera et Species Palmarum*, which has forever associated the name of Martius with the princely family of the Palms, the *Nova Genera et Species Pl. Brasil.* and the *Flora Brasiliensis* now publishing by Martius and Endlicher, which we had occasion to notice in a former volume of this Journal. In the present work, all the known Brazilian plants which are employed medicinally in that country, are systematically considered under the following classes. Class 1. Amylacea; 2. Mucilaginosa; 3. Pingui-oleosa; 4. Saccharina; 5. Acida; 6. Amara; 7. Adstringentia; 8. Acria; 9. Æthereæ-oleosa; 10. Resinosa et Balsamica; 11. Narcotica; with an appendix of Tingentia, or plants employed for their coloring matters. An interesting appendix is added, enumerating the Brazilian equivalent or substitute for the several principal articles of the European pharmacopœia. In connection with the above, we should notice another small treatise of the same author upon the physical

characteristics and temperament, the diseases and the medicine of the aborigines of Brazil, (*Das Naturell, die Krankheiten, das Arztthum und die Heilmittel der Urbewohner Brasiliens,*) which, although published in a separate form, originally appeared as an article in Buchner's *Repertorium für die Pharmacie;* and which appears to contain much curious matter, both for medical men, and for those who are interested in the natural history, the origin, and the fortunes of the American races. A. Gr.

7. *Logarithmic Tables to seven places of decimals, containing Logarithms to Numbers from* 1 *to* 120,000, *Numbers to Logarithms from* ·0 *to* 1·00000, *Logarithmic Sines and Tangents to every second of the circle, with arguments in space and time, and new Astronomical and Geodesical Tables.* By Robert Shortrede, F. R. A. S., &c., Captain H. E. I. C. S., and First Assistant of the great Trigonometrical Survey of India. Edinburgh. pp. 674, royal 8vo. £4 4*s.* in cloth.

The want of such a collection of tables as the above must have been often felt by those who have had much to do with logarithmic calculations requiring peculiar accuracy. The tables of Taylor and Bagay, which give logarithmic sines and tangents to every second of arc, are in quarto volumes of inconvenient size, and on this account can claim hardly any advantage in facilitating trigonometrical calculations over the less extensive and more portable tables of Callet. Though Capt. Shortrede has compressed into an octavo volume of moderate size more than has usually been embraced in bulky quartos, yet the type and arrangement of his work are such that the numbers present themselves to the eye with a good degree of distinctness. And if due care has been taken to render the work accurate, we cannot doubt that it will be received by astronomers and others who have occasion to use logarithmic tables of the larger kind, as better suited to their wants than any collection of such tables previously published. The table of numbers answering to given logarithms, which is introduced into Capt. Shortrede's collection, has been commonly omitted in such works: and though the table as prepared by Dodson and published by itself in a folio volume, has been hitherto of little service to mathematicians, yet presented, as it now is, in a convenient form by Capt. Shortrede, it cannot fail to be found useful. Among the astronomical and geodesical tables accompanying the three principal tables mentioned in the title of Capt. Shortrede's work, there is a very complete table of Refractions, that deserves especial notice. It was deduced by Mr. Galbraith from the well known investigations of Mr. Ivory concerning Astronomical Refraction.

To show the confidence which those concerned in the publication of Capt. Shortrede's tables, have in their correctness, it may be well to give

the following extract from the preface of the work. "It is believed that not a single error of importance will be found in these tables. But for every essential mistake that may be discovered, a complete copy of the whole, with the inaccuracy corrected, will be presented to the individual from whom the communication has been received." It is added, that the author has devoted nine years of assiduous labor and study to the completion of the work, and has expended upon it already more than two thousand pounds.

As it is important that any errors which are detected in such a work as the one before us, be immediately made public, we will here mention two or three that have been observed in it on a cursory examination. In the table of contents, the fifteenth table is said to be on page 603 instead of page 604. In the explanation of the tables, page 4, line 21, for page 143 read page 153. Throughout the third table, in the column which gives the hundredths of seconds of time corresponding to each second in a minute of space, $\cdot 06^{s}$ is made equivalent to $1''$, $\cdot 26^{s}$ to $4''$, 46^{s} to $7''$, &c. We are at a loss to see why 6 is here used instead of 7. What good reason can there be for departing from the common rule, which requires us to use for the last figure of a number, that which will bring us nearest the truth? As there is a uniform practice with regard to this case, in the several thousands of instances which occur in the table referred to, we must conclude that the deviation from the usual course was not unintentional; but the reason for it should have been somewhere stated for the satisfaction of the reader.

8. *The Principles of the Differential and Integral Calculus, and their applications to Geometry.* By Washington McCartney, Esq.—This work though designed for colleges and universities, is somewhat more extensive than the common elementary treatises used in this country; and it may be doubted whether the author has not in this respect misjudged as to the wants of our higher literary institutions. The time ordinarily allotted in them, to the study of the calculus is so short, that no treatise can be thoroughly read by the student, which is not strictly confined to the elements of the subject.

But there are some peculiarities in the work before us, which may give it an advantage over others in common use. Each distinct subject of investigation is stated by the author in a formal proposition, that the attention of the student may be fixed upon what is immediately before him, and that the principles developed may be rendered more prominent and be more easily remembered. It is a common error in treatises on the calculus, to present the elements of the subject too abstractly, furnishing so little of illustration to the student, that he is quite at a loss to see the bearing or importance of much that he is required to learn. In

the treatise of Mr. McCartney, however, geometrical illustrations are introduced at the outset, and are given with great fullness throughout the work. Indeed they constitute much the largest portion of it; as they should do, according to the view which the author takes of the Differential Calculus, when he states that "its object is to determine the properties and relations of lines, and the properties and relations of surfaces, and the relations of lines to surfaces." Though this may not be deemed a just view of the calculus, it will be admitted that the applications of the science to geometry, furnish the best illustrations that can be given of its principles. The work of Mr. McCartney, so far as we have examined it, appears to be well executed, and we would commend it to the attention of mathematical teachers, as furnishing a better view of the applications of the calculus to geometry, than any other work published in this country, with which we are acquainted.

9. *Elements of Geometry; on the basis of Dr. Brewster's* LEGENDRE: *to which is added a Book on Proportion; with notes and illustrations: adapted to the improved methods of instruction in schools and academies.* By JAMES B. THOMSON, A. M., Editor of the Abridgment of Day's Algebra. New Haven: Durrie & Peck—Philad.: Smith & Peck, 1844. 12mo, pp. 237.—This volume is one of the series of Day and Thomson's *Elementary Course of Mathematics for Schools and Academies*, of which the Algebra is already published, and has been received with well-merited approbation. The present work is derived from a treatise of the highest reputation, and retains the spirit and character of its original, while at the same time it is well accommodated to the wants of younger students. Mr. Thomson has performed his task with judgment and skill, and we can safely recommend the work as the best within our knowledge for the class of scholars for which it is intended.

10. *New York Geological Survey.*—The very interesting reports which have already appeared from the different gentlemen in whose hands the several sections of the State were placed, have already been noticed in our former volumes, and we are now in course of presenting a full analysis of their results by an able hand, of which several portions have already appeared. But one most important and indispensable portion of this great work still remains incomplete—a portion which the scientific world will esteem as far the most valuable of all, and on the thorough execution of which the final reputation of the survey will largely rest. We refer of course to the *Paleontology*, of which, although there have been many interesting details, no systematic and comprehensive view has yet been furnished. This portion of the work was originally intrusted to a gentleman of high reputation and

qualifications, who, from causes unknown to us, long since withdrew from the undertaking. *Mr. James Hall*, the geologist of the fourth district, and favorably known at home and abroad for his geological acquirements, particularly in the department of the paleontology of the older rocks, was in May, 1843, appointed to fill the place of paleontologist to the State. He has found it necessary to commence the work anew, and has spent two seasons in revisiting all the localities, particularly in the southern sections of the State. Many new and important facts have been discovered in the course of these researches, and still no doubt much more remains to be done. Already about fifty plates of fossils have been engraved, and these will, it is believed, be ready by July next, with the volume of text which is to accompany them.

This will however be only about half the amount of matter which will finally be required to do justice to the subject. At least one thousand species of fossils are already known within the State, and to figure and describe all these, to compare and collate them, not only with each other but with the most recent and authentic foreign authorities, and to avoid the unpleasant accident of describing anew what is before known, is a work which will require much time and great labor—time and labor which any person in the least acquainted with paleontology can appreciate. The fear is, that an impatience, both on the part of the public and of the state authorities, to see the end of an already protracted survey, will mar the completeness of the result.

As much as we desire to possess the final volumes of Mr. Hall on the paleontology of New York, we should prefer to wait five years more for them, than to have them hurried through the press before the author was satisfied that he had done the best in his power. Who regrets that seven laborious years were spent on the "Silurian system" before its author ventured to put it forth—and who is disposed to quarrel with Mr. De la Beche, that his elaborately minute maps of the English counties, and the corresponding text, proceed at so slow a pace? Nothing valuable to science can be accomplished without great labor, and we trust that both ample time and means will be granted and taken, to complete the survey of New York. She has already done much and well in the cause of science; and we are sure will not permit the full value of former labors to be lost or impaired by an untimely restriction of her previous liberal policy.

11. *United States Exploring Expedition.*—The *Narrative* of this Expedition during the years 1838, '39, '40, '41, and '42, by Capt. Chas. Wilkes, U. S. N., Commander of the expedition, is just about to be published by Lea & Blanchard, in five large imperial octavo volumes with

an atlas. From our opportunities of knowing the extent and value of the labors performed by this expedition, we hazard nothing in saying that these volumes will be by far the most important contributions to geographical science ever made from this country; while the historical and commercial information they contain, combined with the varied incidents of a cruise around and about the world for four years, will render it an attractive book to the general reader. We have some time since laid before our readers a map on which the route of the expedition was laid down, (Vol. XLV, p. 153,) and a summary account of the nature of their labors, (Vol. XLIV, p. 393,) especially in science. It is the less necessary, therefore, to repeat here what has there been stated. The specimen of letter-press and illustration which we have seen is unrivalled in this country for the beauty with which the mechanical and artistic portion of the work has been executed. Forty six exquisite steel plates are interspersed among the letter-press, beside the sixty eight large steel plates, three hundred finely executed wood cuts and thirteen large maps and charts. The letter-press will extend to 2,500 pages. No pains or expense have been spared to make this work in every respect worthy of the subjects it records, and of the government under whose authority the voyage was undertaken. When we have seen the volumes, we shall have it in our power to speak more definitely of their contents. The five volumes and atlas cost $25.

It will be remembered that the work now announced is only the *narrative* of the *Commander* of the expedition, and does not present any of the detached labors of the naturalists and gentlemen of science, connected with the squadron. How many more volumes of text and plates will be necessary to exhibit the full amount of research and discovery made in the several departments of natural history, it is difficult to say. But it is strongly to be desired that no curtailment of these works may be enforced from any false notions of economy, or from a fear that too much time will be lost, if they do not appear at once—before the several subjects have been thoroughly worked up. The character of the gentlemen in whose hands the different departments are placed, is a sufficient guarantee of the faithfulness and ability with which these labors will be performed.

12. *Prof. J. F. W. Johnston's works on Agricultural Chemistry.*—The new editions of the works of this laborious and successful author, have just reached us in an enlarged and improved form. His "Lectures" form an octavo of one thousand pages, and are now every where received as of the most accurate authority, being filled with the most common sense views of the application of science to agriculture.

The unpretending little volume called "Elements of Agricultural Chemistry," has reached its fourth edition and is increased one-fourth in size with new matter. Its extensive circulation in this country, in former editions, is sufficient evidence of the appreciation in which the work is held among us. It is proposed to put forth a new American edition, in which the geological chapters shall be adapted to this country, and a new chapter be added by the author.

Prof. Johnston's "Catechism of Agricultural Chemistry and Geology," seventh edition, has also just appeared, and an American edition is now in press, *with an introduction* by Mr. John P. Norton, a countryman of ours, now a pupil with Prof. Johnston. Mr. Norton has adapted the work for use in this country, by striking out all the local allusions which made it peculiarly British. This useful collection of questions is a very important accompaniment of the Elements.

13. *The Chemistry of Animal and Vegetable Physiology.* By Dr. G. T. Mulder, Professor of Chemistry in the University of Utretcht. Translated from the Dutch by P. F. H. Fromberg; with an introduction by Prof. J. F. W. Johnston, F. R. SS. Lond. and Edin.—This work of the celebrated Dutch chemist is now in press at Edinburgh, and a nearly contemporaneous edition will be issued in this country by B. Silliman Jr., from the corrected proof-sheets of the Scotch edition, which have received the latest correction of the author, and notes by Prof. Johnston. The work is yet unfinished in the original Dutch, and will probably reach near one thousand pages.

It will be published in parts by Wiley & Putnam, and the first part will soon be issued, being already in press.

Having yet seen only the first hundred pages of this eminent work, we cannot speak of it as a whole; but in extent and value of research, in the calm spirit of philosophic deduction which marks its peculiar character, and the absence of wild theory—it stands preëminent among the numerous profound and brilliant works of a kindred character which the last two or three years have produced.

14. *Handbuch einer Geschichte der Natur.* (Manual of a General History of Nature.) By H. G. Bronn. 2 vols. 8vo, pp. 440 and 836, with plates. 1842, 1843. Stuttgart.—Prof. Bronn has comprised within these two volumes a general account of the powers operating in nature, and of the objects which constitute the universe. After devoting a few pages to the fixed stars and space in general, he passes next to our own planetary system, and then to general astronomical, meteorological, and geographical considerations with regard to the earth. The chemical and geological constitution of our globe, and the changes which

have taken place or are now in progress, both in the minute crystallization and the mountain mass, or in the atmosphere, from climate, winds, waters, or internal fires, are reviewed at length and in a philosophical manner by the author. The nature of animal and vegetable life, their distribution over the globe, and the changes they have wrought or have undergone, are also discussed in full. The work, as the name implies, is a general treatise on the agencies in nature and their results, and has a special bearing upon geological science, to which it is a valuable contribution.

15. *A Treatise on the Forces which produce the Organization of Plants, with an Appendix containing several memoirs on Capillary Attraction, Electricity, and the Chemical Action of Light.* By JOHN WM. DRAPER, M. D., Prof. of Chem. in Univ. of New York. Harper & Brothers, 1844. pp. 108, 4to, and Appendix, pp. 216. (3 plates.)

This is a book of no common pretensions. The author states that it embodies the results of ten years of laborious research in one of the most interesting and at the same time difficult departments of natural philosophy. Most of the memoirs on which the views of Dr. Draper are founded, have been published in the London, Edinburgh and Dublin Philosophical Magazine, and are therefore perhaps less known in this country than they are abroad. The volume has reached us at too late an hour to allow of more on the present occasion than a cursory glance at its general scope. We hope to return to it again hereafter. Dr. Draper's reputation as an experimentalist stands high, and his views will meet a respectful attention, however much they may be at variance with preconceived notions.

16. *A Treatise on the Theory and Practice of Landscape Gardening, adapted to North America, with a view to the improvement of country residences, and with remarks on Rural Architecture.* By A. J. DOWNING. Second edition, enlarged and improved, and newly illustrated. New York and London, Wiley & Putnam, 1844. pp. 497, 8vo.

Mr. Downing has had the uncommon merit of striking out a new path of successful authorship in this country, in a field hitherto entirely uncultivated. The appearance of a second and much improved edition in a short space of time from the first, is evidence alike of the public appreciation of the work, and of an unexpected advance in taste on the subject of rural improvements. The number and beauty of the illustrations, the excellent manner of mechanical "getting up" of the volume, but more than all the attractive, easy style of the author, marked every where by a highly cultivated taste, are recommendations which will not fail to address themselves to every reader.

17. *Principles of Forensic Medicine.* By William Guy, M. B. Cantab., Fellow of the Royal College of Physicians, &c. &c. London, Henshaw, 1844. pp. 568, 12mo. $2 50.—This is a clear, well written and well illustrated treatise on the principles of the important branch of medico-legal science. It embraces the most recent views on the complicated and difficult subject of death by poisoning, in all its protean forms. Medical men will be glad to learn that a full supply of the *English edition* can be had of Messrs. Wiley & Putnam, at a very reduced price.

18. *American House Carpenter, a Treatise upon Architecture, &c., together with the most important Principles of Practical Geometry.* By R. G. Hatfield, Architect. 300 Engravings. London and New York, Wiley & Putnam, 1844. 8vo, pp. 254, and Appendix, pp. 32. This is a commendable attempt to render the principles of geometry involved in the carpenter's art practically useful to the intelligent workman, who has had the benefits of only the most ordinary education. Such efforts in this country, where every man is the architect of his own fortunes, are eminently useful, and should meet with ample encouragement.

MISCELLANIES.

DOMESTIC AND FOREIGN.

1. *Soap Bubbles* may be considered as rather a trivial subject of investigation for the profound philosopher, but the ingenious application made of them by Prof. Henry, in solving a delicate problem in physics, will serve to dispel such a conclusion.

In a verbal communication to the American Philosophical Society, (April 5th, 1844,) Prof. Henry stated that very curious notions are given as to the constitution of matter, in the ordinary books on natural philosophy.

"The passage of a body from a solid to a liquid state is generally attributed to the neutralization of the attraction of cohesion by the repulsion of the increased quantity of heat; the liquid being supposed to retain a small portion of its original attraction, which is shown by the force necessary to separate a surface of water from water, in the well known experiment of a plate suspended from a scale-beam over a vessel of the liquid. It is, however, more in accordance with all the phenomena of cohesion to suppose, instead of the attraction of the liquid being neutralized by the heat, that the effect of this agent is merely to

neutralize the polarity of the molecules so as to give them perfect freedom of motion around every imaginable axis. The small amount of cohesion (53 grains to the square inch) exhibited in the foregoing experiment, is due, according to the theory of capillarity of Young and Poisson, to the tension of the exterior film of the surface of water drawn up by the elevation of the plate. This film gives way first, and the strain is thrown on an inner film, which, in turn, is ruptured; and so on until the plate is entirely separated; the whole effect being similar to that of tearing the water apart atom by atom.

"Reflecting on this subject, Prof. H. had thought that a more correct idea of the magnitude of the molecular attraction might be obtained by studying the tenacity of a more viscid liquid than water. For this purpose he had recourse to soap water, and attempted to measure the tenacity of this liquid by means of weighing the quantity of water which adhered to a bubble of this substance just before it burst, and by determining the thickness of the film from an observation of the color it exhibited in comparison with Newton's scale of thin plates. Although experiments of this kind could only furnish approximate results, yet they showed that the molecular attraction of water for water, instead of being only about 53 grains to the square inch, is really several hundred pounds, and is probably equal to that of the attraction of ice for ice. The effect of dissolving the soap in the water, is not, as might at first appear, to increase the molecular attraction, but to diminish the mobility of the molecules, and thus render the liquid more viscid.

"According to the theory of Young and Poisson, many of the phenomena of liquid cohesion, and all those of capillarity, are due to a contractile force existing at the free surface of the liquid, and which tends in all cases to urge the liquid in the direction of the radius of curvature towards the centre, with a force inversely as this radius. According to this theory the spherical form of a dew-drop is not the effect of the attraction of each molecule of the water on every other, as in the action of gravitation in producing the globular form of the planets, (since the attraction of cohesion only extends to an unappreciable distance,) but it is due to the contractile force which tends constantly to enclose the given quantity of water within the smallest surface, namely, that of a sphere. Prof. H. finds a contractile force perfectly similar to that assumed by this theory in the surface of the soap bubble; indeed, the bubble may be considered a drop of water with the internal liquid removed, and its place supplied by air. The spherical force in the two cases is produced by the operation of the same cause. The contractile force in the surface of the bubble is easily shown by blowing a large bubble on the end of a wide tube, say an inch in diameter;

as soon as the mouth is removed, the bubble will be seen to diminish rapidly, and at the same time quite a forcible current of air will be blown through the tube against the face. This effect is not due to the ascent of the heated air from the lungs, with which the bubble was inflated, for the same effect is produced by inflating with cold air, and also when the bubble is held perpendicularly above the face, so that the current is downwards.

"Many experiments were made to determine the amount of this force, by blowing a bubble on the larger end of a glass tube in the form of the letter U, and partially filled with water; the contractile force of the bubble, transmitted through the enclosed air, forced down the water in the larger leg of the tube, and caused it to rise in the smaller. The difference of level observed by means of a microscope, gave the force in grains per square inch, derived from the known pressure of a given height of water. The thickness of the film of soap water which formed the envelope of the bubble, was estimated as before by the color exhibited just before bursting. The results of these experiments agree with those of weighing the bubble, in giving a great intensity to the molecular attraction of the liquid; equal at least to several hundred pounds to the square inch. Several other methods were employed to measure the tenacity of the film, the general results of which were the same: the numerical details of these are reserved, however, until the experiments can be repeated with a more delicate balance.

"The comparative cohesion of pure water and soap water was determined by the weight necessary to detach the same plate from each; and in all cases the pure water required the greater force. The want of permanency in the bubble of pure water is therefore not due to feeble attraction, but to the perfect mobility of the molecules, which causes the equilibrium, as in the case of the arch, without friction of parts, to be destroyed by the slightest extraneous force.

"Several other experiments with films of soap water were also described, which afford striking illustrations of the principles of capillarity, and which apparently have an important bearing on the whole subject of cohesion."—*Proceedings Am. Phil. Soc.*, *No.* 30, *April*, 1844.

2. *Fossil Footmarks found in Strata of the Carboniferous Series in Westmoreland County*, *Pennsylvania.*—We have received from Dr. Alfred T. King of Greensburgh, Westmoreland Co. Penn., an important communication, (which came to hand at too late an hour for publication in this number,) in which he announces the discovery of seven distinct and nondescript footmarks, found on a coarse sandstone of the coal measures one hundred and fifty feet beneath the largest coal seam, and nearly eight hundred feet from the surface of the formation. It

will be remembered that Mr. Logan (Proceedings Geol. Soc. London) found animal tracks on the coal measures of Nova Scotia, (see this Journal, Vol. XLV, p. 308,) which was the first intimation we had of the probable existence of air-breathing animals at any period earlier than the new red sandstone. We have, however, never seen any figures or descriptions of the tracks found by Mr. Logan, nor are they yet published so far as we know. Dr. King's discovery is of great interest, from the novel forms which he represents in the drawings accompanying his papers. Only two of them can probably be referred to a biped animal; these are ornithoid tracks, *similar* to (but not identical with) some of those figured by Prof. Hitchcock.

The other five figures are referable to quadrupeds, of which there are at least four different species, if not genera. His figures (No. 6) are distinctly referable to an animal having the same inequality of step as the Cheirotherium, and other Batrachians. The figures 3, 4, 5, and 7, are probably quadrupedal, but differ entirely from any thing else of the sort we have seen; there is a large circular imprint, surrounded by five toes; in one case circular, in another long and ovate, in a third they are of an intermediate character. The tracks found by Mr. Logan in Nova Scotia were referred by Mr. Owen to the order of Reptilia; some of these may be allied, but others are too anomalous for even a conjecture with regard to their relations. Provisional names are proposed by the author for the tracks. But we will not anticipate the interest of Dr. King's paper, which will be published in our next.

3. *Formula of the Masonite of Dr. Jackson.**—This mineral in its composition agrees with no other. If we allow for a slight deficiency in silicic acid, and suppose the manganese and magnesia to be accidentally present, it evidently consists of simple silicates, and is composed of 2 atoms silicate of alumina + 1 atom silicate of protoxide of iron + 1 atom water, as thus shown:

		Atoms.	Ratio.	
Silica,	33·20	16·60	3	Formula:
Alumina,	29·00	12·88	2	$2Al\,Si + \underline{F}Si + Aq.$†
Protoxide of iron,	25·93	5·76	1	
Water,	5·60	5·00	1	

The specimen analyzed was a portion of a pure crystallized mass, which contained no sensible mechanical mixture, whereby the analytical results could lead to false conclusions as to the specific nature of the

* This notice of the Masonite,—containing additional particulars to those which were given of that mineral in Mr. Alger's edition of Phillips's Mineralogy, p. 132,—was furnished for our last No. but was necessarily postponed.—Eds. Am. Jour.

† The formula of this mineral in chemical symbols is $2\dddot{\mathbf{Al}}\,\dddot{Si} + \dot{F}e^{3}\,\dddot{Si} + 3\dot{\mathbf{H}}$.
—Eds.

mineral. These results certainly do not remove it far from chloritoid, as analyzed by Bonsdorff, and to which Dana* is inclined to refer it; but the complete identity of the two minerals cannot be established, until we have a more perfect description of the chloritoid as to its physical characters. But in any case, the name of Masonite should take the precedence, and chloritoid be viewed as only a variety of it more recently discovered. There is considerable difference in the two analyses given of chloritoid, which renders it doubtful whether it be strictly a definite compound. F. ALGER.

4. *Tenorite.*—This name, in honor of a distinguished Neapolitan botanist, has been given to the black oxyd of copper by M. S. Semmola, who has found the mineral crystallized among the scoriaceous lavas of Vesuvius. It occurs in minute scales from a twentieth to a third of an inch in diameter, often hexagonal and sometimes triangular. *Color* steel gray. *Lustre* bright. Faintly subtranslucent to opaque. It is usually associated with common salt, and is supposed by Semmola to result from the reaction of soda, pure or in the form of a carbonate, on the chloride or carbonate of copper, and to be sublimed along with the salt.—*Bullet. de la Soc. Geol. de France*, t. 13, 1841 à 1842, p. 206.

5. *Sillimanite.*—Dr. Thomson of Glasgow writes to Mr. Alger—"I have been induced by your observations to make an analysis of Sillimanite, to determine whether it contained zirconia. I employed some very pure specimens of crystals, but could not detect any traces of that earth in the mineral. Dr. Muir's analysis therefore must have been inaccurate." It is satisfactory to have a disclaimer of this singular analysis from Dr. Thomson himself. The point however had been abundantly proved before, by ourselves, Mr. Norton, and Mr. Hayes, in the several analyses (q. v.) published in our recent volumes.

6. *Mr. Phillips's Mineralogical Collection.*—The original collection of minerals formed by the late Wm. Phillips, Esq. is at present at the Medical Institution in Liverpool; and Francis Archer, Esq. has recently been appointed to arrange it. The collection was valued by Sowerby at £1300, but was afterwards purchased by Dr. Rutter for £400, and by him it was bequeathed to the Institution. A.

7. *Faye's Comet.*—The comet noticed in our last volume (p. 419) as having been discovered by Mr. Hamilton L. Smith at Cleveland, Ohio, turns out to be that of Faye, who gives the following as its elements, in the Comptes Rendus for September 30th, 1844, p. 665, from observations made in the observatory at Paris:—

* Mineralogy, second edition, p. 523.

Passage of the perihelion, September, 1844,	2·519608	
Longitude of the perihelion, . .	342° 31′ 55″·5	Mean equinox of Sept. 1, 1844.
Longitude of the ascending node, .	63° 48′ 56″·6	
Inclination, ...	2° 53′ 66″·6	
Eccentricity, ...	0·6092118	
Half the larger axis, ...	3.0306258	
Distance of the perihelion, . .	1·1843330	

Time of the revolution 5 years, 3 months, 10 days.

8. *Note from* Dr. Hare, *correcting an error in his Strictures on Prof. Dove's Law of Storms.*

Philadelphia, Nov. 23, 1844.

Messrs. Editors—I beg leave to correct an error committed in my strictures on Dove's Law of Storms, in assuming that the contents of the zones comprised in the same circle between equidistant concentric parallel lines, are to each other as the squares of their mean distances from the common centre; instead of assuming them to be simply as those distances. Of course the velocity of the air in the zone nearest the upward columnar current, in a tornado or hurricane, will not be to the velocity of any greater zone, inversely as the *squares* of the mean distances from the axis of the column; but simply in the inverse ratio of those distances.

Hence, supposing the centripetal velocity at a mile from the centre, to be one hundred miles per hour, at twenty miles it would be five miles per hour, or merely a breeze. By this amendment of the calculation my argument is strengthened, so far as it was an object of it to prove, that in an extensive hurricane the central area, protected by the upward current from the horizontal impetus of the wind, and consequently calm, need not be so spacious as to require more than a very few minutes for it to be passed over by a storm travelling at the rate of thirty miles per hour.

Supposing the wind to blow only from two opposite quadrants, as in the storm of December, 1836, it would of necessity make the distance at which the wind would be reduced to a breeze of five miles per hour, twice as great as that above mentioned.* I am, gentlemen, very sincerely yours,

Robert Hare.

9. *A new Medical Periodical,* to be called "The Southern Journal of Medicine and Pharmacy," is about to be published monthly in Charleston, S. C., edited by J. Lawrence Smith, M. D. and S. D. Skinner, M. D., aided by many able collaborators. The price of subscription is $4 per annum, in advance.

* See Memoir of Prof. Loomis in the American Philosophical Transactions.

ADVERTISING SHEET

OF THE

AMERICAN JOURNAL OF SCIENCE.

A NEW SERIES

OF THE

American Journal of Science and Arts,

WILL be commenced on the first of January, 1846, when the present series of FIFTY VOLUMES will be brought to a close. The FIFTIETH VOLUME of the *Old Series* will consist of a

GENERAL INDEX

to the previous volumes, which will be published near the close of the year 1845 or as soon after as it can be prepared. This INDEX, the preparation of which has been often urged upon us by our scientific friends, is quite essential to the full use of the entire series of volumes, replete as they are with important papers, most of them original American productions. It will contain the fullest references to all the contents and AUTHORS of the 49 volumes which it will cover. Every subject which is mentioned in the entire series, and every author whose opinions or writings are quoted, will be mentioned, and those general principles of good arrangement adopted, which will make it easy to find the word and subject sought.

It is hoped that *every subscriber* will be willing to pay for this volume whether he possesses the entire work or not; for the entire series are to be found in so many public and even private libraries that it cannot fail to be useful to every person having occasion to refer to the records of science for the 27 preceding years. It is only in this way that we can undertake the publication of a volume so expensive to ourselves as this will necessarily be. It will be issued in two parts for greater convenience of transportation by mail, and will be charged at the same price as the other volumes of the series, i. e. $3.

In reference to the *New Series,* we will only say now, that there will be several important changes in it from the present one, designed to make it more valuable and important to all classes of readers. The details of our plan as far as they need be made known will be early announced. One principal motive for commencing this Series is the hope of an increase of our present *very limited* patronage.

Many we trust will be willing to commence with the New Series who have been deterred by the great extent of the present one—not wishing either to purchase so large a number of back volumes, nor to have a broken series in their library. We intend to continue to furnish entire sets of the Old Series.

We respectfully request our friends every where to use their best exertions to obtain subscribers for the NEW SERIES.

B. SILLIMAN,
B. SILLIMAN, Jr. } *Editors and Proprietors.*

New Haven, January 6, 1845.

THE

AMERICAN

JOURNAL OF SCIENCE, &c.

ART. I.—*On Galvanography, or the art of producing from copper plates, formed by galvanic action, impressions from designs painted in the style of sepia sketches;* by Prof. VON KOBELL. Munich, 1842.*

Remark by the Editors.—Perhaps much of the first portion of this article may seem to some of our readers as redundant, in the present state of knowledge of the application of galvanic electricity to the arts. Mr. Spencer's process of electrography has been long before our readers, (see Vol. XL, p. 157,) and many of the details are similar to those here given. But the peculiar and important application which the art has received in the hands of Von Kobell, demands that his statement of his own processes should be left unabridged.

Our readers will appreciate the *practical* value of the memoir. But we would remark, that all the detail of apparatus with diaphragms of parchment and double cells, is now entirely superseded by the subsequent improvements in the electro-metallurgic art. It is now well known that nothing more is needed in the deposition of copper, silver, gold, or other metals, than a simple constant battery whose poles terminate in a neutral solution of the metal to be deposited. This simplification of the method, (which has been brought into use since Von Kobell's paper was

* Kindly translated from the original, by W. G. LETTSOM, Esq., for this Journal.

written,) renders this beautiful union of science and art doubly valuable. We hope at a future time to show some examples of this style of art in our pages.

As indicated by the title, by galvanography I mean the art of so copying in copper, by means of the application of galvanism, pictures executed in the style of water-colors, that from the plates thus produced, impressions may be struck off in the ordinary way.

My first experiments were instituted in the winter of 1839, and the results thereof were laid before the Royal Academy of Sciences of Bavaria, at their meeting on March 14th, 1840. That communication was first published in Nos. 88 and 89 of the Munich *Gelehrte Anzeigen*, and it subsequently appeared in Erdmann's *Journal für praktische Chemie*, (Vol. XX, Nos. 3 and 4, for 1840,) accompanied by specimens thrown off from my first galvanographic plate. The principal points in this paper appeared also in the pages of the French journal *L'Institut*, and in the *Bulletin Scientifique* of the Petersburg Academy, and translations thereof were published in the *Bibliothèque Universelle* of Geneva, and likewise in Sturgeon's Annals of Electricity, No. 27, September, 1840. I may remark, that previous to the publication of the paper in question, no experiments upon this subject had appeared elsewhere.

It was the interesting galvanoplastic experiments of Jacobi, for a detailed account of which I am indebted to H. I. H. the Duke of Leuchtenberg, that first directed my attention to the subject before us, and while occupied in repeating those experiments, I frequently observed that the galvanic copper extended beyond the conducting surfaces and spread itself also over the non-conducting surfaces, of which, especially when not smooth, it formed exact copies.

Turning this remark to account, I endeavored to cover with a deposit of galvanic copper, lines traced upon silver with inspissated oil of turpentine and oxide of iron, and met with no particular difficulty in the experiment. When the edges of the precipitated plate were removed by filing, the two plates might be separated well enough, and I found that the plate thus obtained was sufficiently tenacious and compact to admit of impressions being thrown off from it.

It was not long before I obtained results from which I felt convinced that this process might be of importance in the arts, and my attention was therefore directed to removing the difficulties and overcoming the imperfections that beset me at first, and I now proceed to lay before the public the results of those endeavors.

I must here acknowledge with gratitude the gracious support which the king was pleased to afford me for the prosecution of my experiments; neither should I omit to mention that I am indebted to several artists and amateurs of this city, for the assistance I received from them by their furnishing me with pictures for my experiments. I am also under obligations to my colleague, Prof. von Steinheil, for many friendly communications. The first pictures were painted by Auer, and by Counts Pocci and Spreti.

Before entering upon the subject in detail, it will perhaps not be out of place to say a few words upon the galvanic process in general, as far as we shall have to enter upon it in the following pages.

If a plate be laid in a tamborine and some water acidulated with a few drops of sulphuric acid be poured on it, and if then this tamborine be placed in a copper vessel filled with a solution of sulphate of copper, no action is observed to take place between the copper and the zinc, nor is there any change noticed in the sulphate of copper. As soon however as the copper vessel is brought into connection with the zinc plate by means of a strip of metal, the zinc plate will begin to be consumed, and metallic copper will be thrown down from the metallic salt in solution, on to the copper vessel. The contact of the heterogeneous metals above mentioned, develops therefore in the circumstances in question, a force manifested by the decomposition of the sulphate of copper, and this force is termed a galvanic current. By this force, both the sulphate of copper (consisting of sulphuric acid, oxide of copper and water) and also the water of the solution are decomposed, the sulphuric acid of the sulphate of copper and the oxygen of the water passing through the membrane to the zinc, while the oxide of copper and the hydrogen of the water are carried to the copper of the vessel. The hydrogen, however, reduces the oxide of copper to a metallic state by combining with its oxygen to form water, and

thus the interior of the copper vessel receives a fresh coating of copper, while the zinc plate is gradually dissolved in the form of sulphate of zinc. The two metals therefore, the zinc and the copper, assume opposite characters, the zinc attracting the acid of the sulphate of copper and the oxygen of the water, the copper of the vessel attracting the copper of the sulphate of copper, (due to the reduction of the oxide of copper contained in it by the hydrogen of the water,) and thereby having the thickness of its mass increased. If this process is allowed to continue for a sufficient time, the blue solution of the sulphate of copper is at last deprived altogether of its color and does not contain any more copper at all, after which no further change is observed.

Such an arrangement of the galvanic apparatus is termed a *simple circuit*, and it is said to be *completed*, when the zinc is brought into connection with the copper by a strip of metal as described above.

If upon the bottom of the copper vessel another piece of metal be laid, for instance a plate of lead, platina, silver, gold, &c., it will be found that when the circuit is closed, this plate becomes coated with copper derived from the solution of the sulphate, which is a proof that it assumes the same condition as the copper itself with which it is in contact. Such substances therefore *conduct* the galvanic influence through their mass, and are therefore called *conductors*. Whereas if a piece of glass, quartz, porcelain, wax, stearine, &c. be laid upon the bottom of the vessel, it will be found when such substances are present of a considerable size, at least, that no deposit of copper takes place upon them, and hence they are termed *non-conductors* of the galvanic influence. All metals are more or less good conductors; of the non-metallic bodies, plumbago and charcoal—the latter especially in the form of coke—are good conductors.

When the surface of a non-conducting body is coated with a conductor, copper will of course be deposited also thereon, so that it is only necessary to invest the surface of wax, stearine or other non-conductors, with a good coat of plumbago, of silver powder, bronze powder, or some such substance, in order to precipitate copper upon them.

If a strip of copper is made fast to the zinc plate of the above described apparatus, and another strip in like manner to the copper vessel, and if these strips instead of being united in the way

before mentioned, by a binding screw, are both led into a second vessel filled with a solution of copper and placed opposite to each other, without however being brought into contact, we shall see that in this case too, a decomposition of the sulphate takes place. Copper will be deposited upon the strip leading from the zinc, while the sulphuric acid passes to the strip proceeding from the copper and dissolves it, forming thereby fresh sulphate of copper, and this action goes on till the strip is consumed. Here therefore, for reasons which it would take up too much time to enter upon, the galvanic condition of the strips is no longer the same as that of the metals in the first vessel with which they are in connection, and instead of the circuit, as was the case in the first arrangement, being completed by means of a strip of metal connecting the copper and zinc, the circuit is here completed by the fluid forming the metalline solution. It follows of necessity, then, that the solution of sulphate of copper itself is possessed of conducting power, and there are many other methods of proving this fact. For instance, if we place a piece of glass on the bottom of the copper vessel, connected as has been described above with the zinc plate in the tamborine, and then lay a silver plate upon the piece of glass, the metal plate will after a certain time receive a coating of copper, and this though not in metallic connection with either its sides or its bottom. Galvanic copper is in like manner precipitated on the sides of the copper vessel, if a piece of glass is laid on its bottom and on that a plate of copper connected with the zinc plate in the tamborine, but not touching the sides of the vessel.*

By both these methods, plates and coats of galvanic copper may be obtained, and the arrangement last described may be so disposed as to admit of the deposition of the copper being observed with facility. At first the copper deposited from the solution appears in the form of a reddish film upon the conductor, and there is gradually formed a thin plate of a pale flesh color; by degrees the thickness of this plate goes on increasing, and small nodules begin to form upon it which keep enlarging continually if they are not brought down from time to time by the

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* I have sometimes observed that a portion of the side of a vessel becomes in some parts positive and in other parts negative, the portion thereof in the vicinity of the connecting strip proceeding from the copper plate being corroded, and copper being precipitated on the opposite portion.

application of a file. From the condition of the copper, it is evident that its precipitation takes place in the form of an infinitude of extremely minute crystals, to the accumulation of which the nodules and other asperities of the surface are to be ascribed. As the deposit thus made has a tendency, especially at the first stage of the progress, to spread out laterally, we observe, as has already been remarked, that non-conducting surfaces also, when interspersed at intervals with places that do conduct, and when resting on good conductors, receive a similar coating of metal. As soon as such non-conducting spots, however, begin to assume the form of rounded masses, the lateral extension decreases very materially and an increase takes place in the thickness of the deposit.

Now the quality of a galvanic plate depends upon the size, or rather the uniform aggregation of these crystals, and this is principally influenced by the strength of the galvanic current and by the amount of resistance offered to its passage. Both these circumstances are dependent on the dimensions of the pair of plates and of the connecting strip; on the distance between the zinc and the other—the negative—plate; on the nature and on the concentration of the fluids employed, as also on their temperature; on the quality of the diaphragm interposed between them; and finally, on the nature and the surface of the colors employed, supposing that a picture is to be coated and have a copy taken from it.

If a completely constructed and equable current were requisite for obtaining a serviceable plate, these galvanic precipitations would not, in all probability, come readily into practical use; for the strength of a current depends upon a great variety of circumstances, many of them extremely slight, as any one may convince himself, by the employment of a galvanometer. Happily, however, it is constant enough for our purposes, namely, for the production of a plate of sufficient coherence to resist the treatment to which it is subjected by the copper-plate printer, and of sufficient tenacity not to be liable to bend in passing between the rollers; and it is, moreover, a fortunate circumstance, that it is matter of complete indifference whether the first film of copper thrown down into the picture, and taking a perfect copy of it, is of malleable and elastic metal, or brittle and fragile, provided the farther thickness deposited thereon possesses the requisite properties.

As it has been my object to render the production of these plates dependent as little as possible on the attention of the experimenter, and on the dexterity of his manipulation, I have selected the process which admitted of the simplest and most convenient form of the apparatus employed.

1. *The galvanic apparatus.*—The apparatus which I employ consists of a simple circuit. The various parts of which it is composed are—

(1.) A vessel of well burnt clay, with a flat bottom, whose sides are from five to six inches high. The interior of this vessel is to be coated with a mixture of wax and asphaltum. The dimensions of the vessel depend upon the size of the plates it is proposed to form. Those which I have hitherto used were circular, and about eighteen inches in diameter.

A vessel suitable for large plates may also be employed for small ones. Vessels of glass or china would of course be preferable to clay ones. They may likewise be made of copper, in which case, however, they must receive a coat of good tenacious varnish.

(2.) A parchment tamborine, with a wooden frame, standing on three feet, about an inch or an inch and a half high. The rim or hoop of the tamborine is about two inches high. What answers, however, better than this, is a sugar-basin of a suitable size, cut off at the proper height, and with parchment stretched upon it. It is to be placed on a tripod rendered insulating by the application of a coat of wax, or it may be suspended by wires in the outer vessel. Instead of parchment, two ox-bladders, one stretched over the other, may be used. The tamborine should be large enough to take in the whole of the plate to be prepared; it may, however, be larger.

(3.) A plate of copper, on which the painted plate is to rest. This plate must be half an inch or an inch wider in every direction than the painted plate, and should terminate in one or two strips of copper, an inch and a half wide and five inches long. These strips are to be bent up at a right angle.

(4.) A zinc plate to be put into the tamborine, and supported above the parchment by a glass rod, about one third of an inch thick, bent into a square or a triangle. The plates I have hitherto used were of rolled zinc, and one twelfth of an inch thick. In my earlier experiments I used to amalgamate them, but now I do not.

For large or heavy plates it is necessary to use a frame of copper wire, so suspended from the sides of the tamborine, that the due distance of the zinc above the membrane may be secured.

(5.) A strip of copper or lead, half a line thick and an inch or an inch and a half wide, terminating in a round plate of half the size of the zinc plate. This plate is six or seven inches long, and is used for closing the circuit. For that purpose, the broad end of the strip is to be laid upon the zinc plate, the other end thereof being connected by a binding screw, with the strip of copper described under (3). This plate of copper may also be made to terminate in two strips, in which case it is to be connected with a similar double strip, proceeding from the bottom plate, (3).

(6.) The solution of copper from which the galvanically precipitated copper is derived. This I term the precipitation fluid. In my early experiments I employed a saturated solution of the sulphate of copper, and round about the plate I laid crystals of that salt, so as continually to renew the quantity of the sulphate decomposed in the fluid. I then, however, frequently obtained a very brittle copper, which, at an early stage of the process, became covered with nodules, and I have found it a better plan to employ a saturated solution without the crystals as above described, and to renew the solution in a day or two. Such a fluid is weakened, it is true, by the continual deposition of the metal, and its conducting power, therefore, keeps gradually diminishing. In order to attain a uniformity in the current, I tried what would be the effect of adding to the solution of the sulphate of copper, other salts which resist the action of such feeble currents as are here called into play, and I thus obtained a copper of the most admirable quality. The salts I thus employed were Glauber's salt, sulphate of zinc, potash alum, and saltpetre. Chlorides are not available, for they become decomposed, and thus act on the silver on which the pictures are painted. These salts, or rather their saturated aqueous solutions, with the exception of the sulphate of zinc, take up as much sulphate of copper as common water does. I have determined the amount of oxide of copper contained in an ascertained quantity of those solutions, and have ascertained therefore by calculation what is the quantity of sulphate of copper which they take up. I find that 100 parts by weight of spring water dissolve about 27 parts of sulphate of

copper,—100 parts of a solution of Glauber's salt 27·5,—100 parts of a solution of potash alum 27·4,—100 parts of nitrate of potash 25·4; but 100 parts of sulphate of zinc only 7 parts of sulphate of copper.

As a precipitation fluid, there are two mixtures which I usually employ, the first consisting of two parts by measure of a saturated aqueous solution of sulphate of copper, mixed with one part by measure of a similar solution of the sulphate in a solution of Glauber's salt; the second consists of the same quantity of the solution of the sulphate of copper, with the addition of one part by measure of a solution of the sulphate in a solution of sulphate of zinc. There are however other proportions, for instance equal parts by measure of the various solutions, which afford satisfactory results; indeed a simple solution of sulphate of copper in a solution of Glauber's salt will afford an extremely malleable copper, which, when as much as half a line thick, is perfectly flexible, and presents a very even surface.

The vessel in which the copper plate and the painted plate lie, is to be filled with the precipitation fluid, till the parchment of the tamborine standing therein is covered to the depth of some lines. The tamborine must be so constructed, that on dipping it down into the liquor, no air may be retained below the parchment. After the lapse of two or three days the liquor must be changed, and fresh sulphate of copper be dissolved in the fluid removed. The vessel therefore is to be of a sufficient size to admit of a suitable quantity of copper being furnished for that period. If the bottom of the vessel is about three times as large as the copper plate upon which the picture rests, the quantity of the solution it holds will be sufficient; it may, however, be larger.

The precipitation of the copper is carried on without any motion in the fluid, so that under certain circumstances the density thereof may be very variable. On one occasion I employed a tall cylindrical glass vessel for making such a galvanic deposition, and so placed the plate on which the copper was precipitated, that there were equal quantities of the solution both above and below it. As I allowed the action to go on without interruption, I found the whole of the copper precipitated out of the fluid between the zinc and copper plates, the liquor losing its color alto-

gether; whereas the solution below the copper plate was of the same blue color that it had at the beginning of the operation.

Should the fluid not be renewed, the last portion of the copper thrown down is not obtained in a sufficiently coherent state, but there is deposited upon the plate a dark-brown voluminous slime. This precipitate consists chiefly of metallic copper, and should the deposit not be too thick, it may be brought to unite together, by renewing the precipitation fluid and employing an energetic current. In such a case, however, it is advisable to wash off the slime with water, and, having dried the plate, to give it a brilliant surface by the use of the scratch-brush, and then replace it in the apparatus.

(7.) The fluid for the zinc plate in the tamborine, or *exciting fluid.* For this I employ water acidulated with sulphuric acid. To a pound of water is added about $\frac{1}{12}$ or $\frac{1}{14}$ of an ounce of English sulphuric acid. This mixture is to be poured over the zinc plate, and the leaden plate placed thereupon, and it is well that the fluid in the tamborine should stand somewhat above the level of the precipitation fluid; otherwise, undecomposed sulphate of copper makes its way to the zinc, and the current is thereby reduced in energy. This exciting fluid is to be renewed every day, and that which is saved may, if thought worth while, be evaporated for the sulphate of zinc which it contains.

In addition to this apparatus, the formation of these galvanic plates requires a pair of pincers in order to remove the plates from the fluid, inasmuch as it might prove injurious to wet the hands too often with the copper solution. It is best to have copper pincers. A few fine and coarse broad files are likewise wanted, as are also a scratch-brush and other brushes, a vice, and a pair of shears for cutting the plates.

A representation of the apparatus, and a detailed description of it, is given at the close of the paper.

In using the apparatus, the following remarks must be attended to. The tamborine is to be taken out of the fluid every twenty four hours, and the zinc plate cleaned with water and a brush. The parchment and the leaden plate are to be treated also in the same way. This having been done, and the exciting fluid renewed, the zinc and the lead plates are to be replaced in the apparatus. Should the lead plate become speedily coated with a red film, or the upper surface of the zinc turn blackish, it is a

proof that the solution of copper has found its way through the sides of the tamborine, or that there is a rent or minute holes in the parchment. Such a tamborine is to be laid aside, as must also those on the parchment of which there is an abundant formation of nodules of copper.

These nodules are not produced when the glass triangle below the zinc is made of a cane of sufficient thickness, nor unless the action is allowed to continue till the zinc plate is entirely consumed. I always put on a new zinc plate when the old one begins to be thin; and this, with such plates as I use, takes place about every other day. What remains of the plates may be remelted for forming new ones.

The strip proceeding from the leaden plate, as also that portion of the copper plate which is screwed thereto, are to be kept bright, and the leaden plate from time to time is also to be made bright by the use of a file.

The galvanic copper is in the best state when of a pale flesh color, and when, if on being rapidly dried, it assumes a dull metallic lustre; if brownish red or dull, it is brittle and friable, and there is then something wrong either in the tamborine* or in the state of concentration of the precipitation fluid, or perhaps the zinc plate is too much consumed, or the leaden plate and the connecting strips are not clean enough, or may be the tamborine is inserted too deep in the fluid.

In a case like this, the plate is to be dried and rubbed with a scratch-brush, till it is again bright, and after correcting such fault as there may happen to be in the apparatus, the deposition is to be allowed to proceed.

It must be further observed, that what has been here said respecting the fluids employed, the distance between the plates, the connecting slips, and so forth, is applicable only to such an arrangement of the apparatus as is here described; any essential modifications thereof would naturally carry with them various modifications of the details here given.

2. *Of the colors and the method of painting.*—A color used for the preparation of a picture to be galvanically copied, must possess the following qualities. 1st, it should adhere well to the

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* If a clean strip of zinc inserted into the tamborine turns grey within five minutes, there is something wrong in the tamborine itself or in the membrane. If the strip remains bright, the fault is in some other part of the apparatus.

metal; 2d, it should be insoluble in the precipitation fluid; 3d, its surface should be dull when dry; and 4th, it should to a certain extent possess a conducting power. It need scarcely be remarked that a soluble paint, or one that does not adhere entirely to the surface on which it is laid, is quite inapplicable for such a purpose; for, in the latter case, copper insinuates itself beneath it, and instead of a sunk surface, there is produced a flat one, or one that is neither one thing nor another: in the former case, we obtain no picture at all. It is a matter of not less importance that the paint should dry with a dull surface. This is equally indispensable, both for the production of good plates, and for obtaining satisfactory impressions. It has been already remarked, that the galvanic deposit of copper consists of infinitely minute crystals, which, having once begun to form, attach themselves, as does every other substance under the influence of crystallization, far more readily to rough than to smooth surfaces, supposing the latter not to be possessed of conducting power.

If a brilliant varnish is employed with the color, copper it is true may be thrown down upon it, not however without difficulty, and we soon see that the little nodules deposited in the first instance, have a far greater tendency to increase upwards, than to extend themselves in a lateral direction. This leads to the formation of spherical aggregations, which, with a long continuance of the process, to a certain extent it is true, unite, but between which little holes are frequently left upon the surface of the picture, which do not fill up, and which, when the plate attains a certain thickness, become arched over, as it were. This naturally delays considerably the complete coating over of the picture, and as the metallic portions conduct with far greater readiness than the vacant spaces, frequent recourse to the file becomes requisite, thus rendering parts already covered liable to be again detached. These nodules moreover do not present a truly uniform surface below, but have always a tendency to radiation from a central point, so much so indeed, that it is sometimes visible in impressions taken from such a plate.

If by any means these vacant spaces have a conducting power imparted to them, a galvanic plate may, it is true, be formed easily enough; one however that does not answer well for taking impressions from; for, on washing the plate, the whole of the ink is removed from these former hollows. No copper plate is fit for

printing from, unless the design upon it has been rendered dull by etching, (that is to say, has a grained suface,) or unless lines or strokes are cut in it, as in etching or engraving. And from the condition which an etched plate presents, it is evident that metals thus treated consist of infinitely minute crystals, otherwise there is no reason why a smooth surface should become rough and dull by that operation, as we know it does. Crystals, as we are aware, are however more easily acted on upon their planes, than upon their angles and edges. It is an aggregation of crystals thus undergoing solution to a certain extent, which is the cause of the roughness or dullness in question.

Painting therefore with a color that dries glossy, as most oil colors do, can only be had recourse to for obtaining plates for impressions resembling etchings. If it is desired to form with a glossy color a picture in the style of Indian ink, a grain must be given to it previous to its receiving its coating of copper. This is done by dusting it over with some substance in the form of powder. I have employed for this purpose pulverized plumbago, fine silver dust, and also iron in that minutely divided state in which it is sold at the apothecaries under the name of *ferrum alcoholisatum*. A tube of four or five lines in diameter, and at one end covered with a bit of fine crape, either single or double, is used for applying the dust. A portion of powder in the tube is to be sifted on to the picture until the entire surface is thinly covered over therewith; and the greasier the surface is, the more readily this metallic dust adheres to it. I have thus prepared several pictures painted in burnt sienna, that color being very well suited to the purpose, owing to its transparency, which renders it necessary, where a deep tint is required, to lay it on so thick as to produce a somewhat raised surface. The iron powder, which in the fluid is very soon replaced by copper, did not, I found, answer so well as the plumbago or silver—it led to the formation of air-bubbles, producing little holes or indentations in the plates.

Although by suitable treatment good impressions, faithfully reproducing the original, may by this means be produced, it is clear that to a certain extent the original is nevertheless modified. I therefore endeavored to find out colors better suited for this purpose, and the result of my enquiries is, that those prepared for encaustic painting answer better than any others. The encaus-

tic mass with which these colors are ground up and prepared in the manner of oil colors, consists of a solution of wax in oil of turpentine, to which is added a certain quantity of Damara-gum varnish. Of this preparation only so much is to be used that the color when applied to glass may be *dull* when dry, and yet enough that it may adhere firmly after being allowed to lie twenty four hours in water, or in a solution of sulphate of copper. The coloring material itself is not altogether a matter of indifference; oxide of iron, or most of the ochres, Cassel brown, charcoal, coke, or Frankfort black, are the colors that answer best. I had prepared in the same way plumbago in powder, and also silver and iron-dust, and found that as they dried, these substances made their way enough to the surface to prevent their conducting power being altogether suspended by the thin film of wax with which they were invested.*

The best of these substances is plumbago, and from its color it is peculiarly suited to deepen the shades, which are the only portions (owing to their forming the thickest coats) that require a conducting power being given to their surface; all the parts where the coat of paint is but thin become coated over with copper without help. This last remark, however, applies only to certain substances, the colors enumerated, for instance; where to a certain extent the deposition of the metal is furthered by the porosity of the surface, aided by the circumstance of their not being altogether complete non-conductors. Whereas, in consequence of its complete power of insulation, a film of mica, be it ever so thin, receives no deposit of copper if placed upon a silver plate, while a far thicker coat of a color prepared as above becomes gradually coated with metal.

The picture is simply to be painted with one of the above colors, which are used with oil of turpentine. The oil should have a little resin or wax dissolved in it, in order to give the color more consistency, for it is of course above all things requisite that it should adhere firmly to the ground on which it is laid. The color that I have oftenest used is oxide of iron. The picture is executed in the Indian ink manner, and the places left bare on the metal upon which one paints, correspond therefore

* Paints thus prepared are to be had in bladders, of Kern of Munich, under the name of galvanographic colors.

to the highest lights. The shades are laid on according to their depth, and when the picture is completed, these portions are to be farther treated with plumbago, as has been described. The picture thus prepared should be dull on its surface, and should there remain on the thicker portions of the paint any glossy parts, they are to be deadened by a further slight application of the black-lead paint.

When large portions of the picture are occupied with very deep shades, the following process is necessary. The picture being otherwise complete, the shades in question are to be painted over with some unctuous oil color, (sienna answers very well,) fine black lead powder is to be sieved over the surface, and what does not adhere to those places to be thrown off by giving the plate a few gentle blows. The parts thus prepared present a velvety appearance, and enable us to produce the deepest shades with the utmost facility.

The picture is to be painted upon a finely polished silver-plated copper plate, similar to those used for the Daguerrotype, the color being laid on upon the silvered side. To avoid the unpleasant glare from this plate, its entire surface, with the exception of the highest lights, may receive, when the picture is sketched in, an extremely thin film of color.

It must be borne in mind while executing the painting, that the impression obtained from the copper plate always proves somewhat paler than the original, the reason of which does not lie in a want of truth in the copy, but rather in the necessary wiping of the plate, in a certain portion of the ink being absorbed by the paper, and so forth. No other colors than those enumerated are to be used in a painting, and it is detrimental to give the surface of the silver a coat of varnish.

The method of transferring a design to a plate is as follows. The back of the paper is to receive a coat of dark colored oil paint, which is rubbed in with wool till it no longer soils the fingers, and the picture is then to be pricked through on to the plate with a sharp point of wood or other similar instrument.

It does not answer to use a pure copper plate instead of a plated one, but a copper plate platinized or coated with silver, as described under (5), will do very well. Were a simple plate of copper used, there would be a risk of injuring the deposited plate in detaching it from the painted one, especially where many

blank spaces of considerable size are left in the picture upon the latter.

But as the process does not in any case injure a plated plate, unless indeed the highest lights are scratched out with a graver or other hard pointed instrument, the use of a plated plate is to be preferred, inasmuch as after it has served it may, should occasion require it, be cleaned with ether or rectified oil of turpentine, and again polished without difficulty. I may here mention an interesting case that occurred to me, on an occasion where I was experimenting upon a painted plate of pure silver. It was placed on the somewhat uneven bottom of a copper vessel serving for the galvanic apparatus, thus allowing the fluid to get beneath it. Its under surface was not polished. The upper surface exposed towards the zinc became coated with copper, while on the lower side the silver was gradually taken up and again deposited upon the sides of the copper vessel in the form of mossy aggregations. I have never noticed any such corrosion of the lower surface where pure copper or plated copper plates were employed.

3. *Of the further treatment of the painted plates, and of the manner of placing them in the apparatus.*—Where many lights or faint tints occur in a picture it is unnecessary to heighten the conducting power of its surface, more especially when the deeper shades have been touched up with the black-lead paint in the manner above described, and when also the color adheres sufficiently to the ground. In a picture, however, where the lights are but few, or where the entire surface of the silver is coated with color, it is advisable, if only indeed to a limited extent, to give the picture a certain conducting power, for the quicker the plate is coated over, the more perfectly the picture is copied.

I have taken considerable pains to find out a method of producing a film of metal on the painting by chemical means, but there are many difficulties in the way of this, owing to the colors employed not becoming melted by aqueous solutions. To this end I laid the painted plates in flat vessels, and poured on to them solutions of the acetate, the nitrate, and the formate of silver, and then by exposing them to the light I brought about a reduction of the silver upon the surface of the color. The success of the experiment was only partial; for there were frequently formed minute crystals of silver in groups, instead of a uniform coating of that metal. Repeated experiments have however con-

vinced me that by the use of pulverized dry black lead, we completely attain the end in view. In the absence of other auxiliary circumstances, for instance, the good conducting power of silver plate beneath, the action of the plumbago would not suffice for the production of the film of metal, more especially as the colors are so little of an unctuous nature that the plumbago when dry will adhere to them in only very minute quantity.

In order to apply this process to a picture, some finely powdered black lead is worked into a bit of soft untanned leather by rubbing it upon a piece of paper, and then gently dabbed on to such places as require it, these parts being in a suitable state of dryness.

The picture by this means is invested with an almost imperceptible gray coating, so fine that the design of the plate is no ways injured thereby, (as may be seen by examining it with a magnifying glass, or as proved by the subsequent impressions thrown off,) but which is nevertheless sufficient for facilitating the deposition of the precipitated metal as much as is necessary. In cases where it is requisite to deepen certain shades, as described above under (4), it is to be done subsequently to the operation just mentioned.

It might be imagined that the application of these disconnected particles of black lead would have but little influence in contributing to facilitate the precipitation, whereas we easily see how this substance favors the deposit upon a wax surface when well rubbed into it—an operation to which we cannot submit these pictures without injuring them. The reason why the minutely divided plumbago is of service, is due partly to the fact that the atoms of copper thrown down, as they form a mass by aggregation, are brought into contact with neighboring particles of plumbago, thus making a conducting connection, and by a repetition of this operation causing the surface to be coated over: and partly, as shown by the experiments above performed, to this; that the solution of sulphate of copper bringing these conducting particles into connection with the uncoated places of the copper and silver plates, serves as a base beneath, without being in immediate contact with metals, just as a silver plate becomes coated over when allowed to rest upon a glass plate (a non-conductor) on the bottom of a copper vessel, forming a closed circuit with the zinc plate. This kind of picture may however be laid on

altogether in plumbago of various degrees of fineness, and when thus executed there is no difficulty in causing the copper to form upon it.

When the picture, ready for receiving its metallic coating, is placed in the apparatus, care must be taken when letting it down into the fluid to detach the bubbles of air which adhere to the paint, and this before closing the circuit; for should this precaution be neglected, these bubbles become themselves coated with copper, and holes are thus formed in the plate. These bubbles may be removed with a brush, or by alternately dipping the plate into the fluid and again withdrawing it; but it is still better to prevent the bubbles from forming, which may be attained by exposing the plate to the vapor of hot water prior to its insertion in the fluid. There is a condensation of water upon the plate, and as soon as the uncoated spaces thereon are observed to be covered with these globules, it is to be lowered into the fluid, after which it is but seldom that air bubbles make their appearance.

As was observed in (3), under the head of *galvanic apparatus*, the picture must lie upon a plate of copper larger than it, half an inch or an inch every way. The back part of the edges of this base should receive a coat of melted wax, laid on with a brush, so as to produce insulation; the connecting strip too is to be treated in a similar manner, excepting of course the portion protruding above the fluid where the binding screw is attached. Were the base only of the size of the painted plate, or smaller than it, the latter would have thick knobs formed along its edges, and shoots of metal would push out from its corners, which it would not be easy to remove with the file. When the base has been in use for some time, similar knobs and nodules of copper form upon the waxed portions thereof, more especially towards the edge. These are to be removed with a chisel from time to time, and if the coat of wax on the edge is not too thin, they may be very easily detached.

Before inserting the plate in the fluid, it is a good plan to set the apparatus in action for half an hour or so, by connecting the strip of lead with the copper strip proceeding from the base.

The method in which the copper spreads over the surface of a picture prepared as here described, differs to some extent from the way in which that metal spreads itself over a cast in stearine that

has received a coat of black lead. In the latter case, the deposition of copper proceeds from the strip of metal by which it is surrounded, and extends itself with a kind of negation as it were, till the entire surface is coated over; while in the case of a prepared picture, though near the uncoated places something of a similar course is observed, there is formed a thin film upon the general surface of the plate, as if minutely divided copper had been sifted over it. This film gradually thickens, until it forms a plate capable of furnishing impressions. From this we can clearly trace the influence which is exercised by the metal surface upon which the color is spread, as also the propriety of employing colors possessed of a certain amount of conducting power. The copper dust just alluded to, consists of metal in an infinite state of subdivision, of atoms or molecules of copper, and hence we see that we can by no means supply its place by mechanically prepared copper powder, which when sprinkled on the picture will, it is true, unite so as to form a plate, but not one which furnishes an accurate copy of the original.

A picture rightly handled is coated over with copper in most places in twenty four hours, and in two days this drawing is complete; on the third or fourth day little nodules or other asperities begin to make their appearance. To get rid of them, the plate is to be taken out of the fluid and dried, and the surface having been rendered smooth with a fine file, the plate is to be replaced in the apparatus. With small pictures, the copper deposited in from four to five days, attains sufficient thickness to admit of its being removed, but with pictures of larger size the process should be allowed to go on for six or eight days. It is advisable to lay a strip of silvered copper (5) in the apparatus, in the vicinity of the painted plate. After the lapse of four days, the copper upon this strip is to be examined with the file. If it is flexible, it is a sign that the plate thrown down upon the picture is fit to be taken off, supposing at least that it has attained a suitable thickness; if the copper on this test strip is, on the contrary, brittle, the deposited metal upon the picture must be allowed to increase in thickness prior to removing it.

Should it ever happen that, after two or three days' action, small spots are not covered with metal, the picture is to be taken out of the fluid and dried. Silver, in the form of very fine powder, is then to be sprinkled upon the refractory places, and this

causes them to receive the copper without difficulty. From a careful examination it will be always found that a spot which, after the action has continued some time, still remains bare, has not the requisite roughness of surface, or that too much resin has been dissolved in the oil of turpentine employed in the painting. In order to make the silver powder adhere properly, the places where it is to be applied may be very slightly damped with oil of turpentine.

4. *Of the removal of the galvanic plate and its treatment till taking impressions from it.*—When the deposit of copper has attained a sufficient thickness to form a plate from which impressions may be thrown off, the two plates in their united condition are to be taken out of the apparatus, wiped dry, and screwed tight in a vice between two boards, in order to separate them by the use of a file. A broad file is to be applied to the edges, and when the galvanic copper that laps over on the back of the silvered plate comes off in flakes, it is a sign that we have come down to the painted plate. If these flakes are, as is ordinarily the case, very pliable, the metal thrown down is known to be of good quality; while, on the contrary, should the flakes turn out brittle, we know that the copper plate precipitated is so too, and therefore liable to be broken if too thin.*

When the edges are filed off, the two plates are to be separated by inserting the thumb nail or a piece of wedge-shaped wood at one corner. In general the plates may be separated without difficulty; sometimes indeed they fall apart. If the deposited plate is too thin, it is easy to increase its thickness, by carefully coating the picture side with melted wax, and laying strips of lead crosswise across it, and bending them back so as to be in contact with the back of the plate towards the edge. Thus prepared, the plate is to be replaced in the apparatus till the metal attains the substance desired. The lead strips are easily detached, and the wax is to be removed by carefully wiping it off the plate when made hot.

Sometimes the picture remains tolerably perfect on the silvered plate after the removal of the copper one, but generally speaking the color adheres to the hollows formed in the latter. It is to be

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* The specific gravity of good pliable galvanic copper was found = 8·9, while a very brittle plate was only = 8·7.

removed by the application of sulphuric ether rubbed on with a flock of cotton, and the surface is then to be gently rubbed with soft leather dipped in calcined hartshorn shavings or finely levigated quick-lime. The plate is then ready for the printer. The press employed is the ordinary copper-plate printer's press, in which the paper lying below the inked plate is made to pass under a metal roller. The plate becomes slightly bent thereby, not however more than it will readily bear, even should the metal be brittle, if it is only of sufficient thickness.

5. *Of corrections and alterations introduced into a galvanic plate.*—It need scarcely be remarked, that by the use of the scraper and burnisher, or of the etching-needle and graver, a galvanographic plate may be corrected and touched up, just as an ordinary etched plate may be. There is, however, another simple method in which one of these plates may be corrected, and have any alteration we like introduced into it, namely, by taking a second galvanic copy thereof.

The picture side of the plate is to have thrown down into it a coating of metallic copper, the suitable thickness of which is attained in the space of two or three days.

This second plate gives, in the strictest sense of the word, a perfect metallic copy of the original picture. In this copy the desired corrections are to be made, either by again having recourse to the paint-brush, or by the use of the scraper or burnisher, as the case requires. A second plate thrown down on to this relief as before, will naturally furnish impressions containing the desired alterations. Occasionally, however, the two copper plates thus prepared adhere together so firmly, that there is no possibility of separating them; but this difficulty is altogether obviated by the following process, which was first communicated by me to the Academy of Sciences, at their meeting of the 11th December, 1841.

If we form a concentrated solution of common salt, and dissolve chloride of silver in it, (this is done by adding thereto a suitable quantity of a solution of nitrate of silver, shaking the precipitate well up in the fluid, and then letting it settle,) and into this liquor dip a clean strip of copper, it will be observed that in from ten to fifteen minutes there forms upon the surface thereof an infinitely thin film of firmly adhering metallic silver, so thin, that on washing the plate, and drying it with a towel,

and rubbing it with a piece of wash-leather, it presents the appearance of copper again.

A similar coating of platina may be obtained by adding to a similar solution of salt, (till the liquor assumes a pale wine-yellow color,) a few drops of a solution of platina as neutral as possible. About one eighth of an ounce of the solution of platina is required for a pound of the solution of salt. It takes about two hours for the film of platina to form completely upon the copper plate, but it adheres as well as the silver if not better. In order to clean properly the plates thus coated, they are to be laid for five or six minutes in diluted muriatic acid, and then washed in warm water. If, when thus washed, they assume a bluish or yellowish hue, they must be again dipped in the diluted muriatic acid, and washed in cold water. The deposition of this film of silver or of platina is very materially influenced by the quality and the nature of the copper surface; but it is precisely upon this galvanic copper, owing to its purity, that these films are thrown down in the most perfect state, and as they form most readily upon smooth surfaces they prevent the plates from growing together at the very spots where their tendency to adhere is the greatest. Any thing approaching a modification in the copy is out of the question by this process; for, strictly speaking, these films are not coats upon the copper, but rather they replace a portion of that metal from the surface of the plate, inasmuch as there is an interchange between the atoms of platina or silver in solution and those of the copper.

In order therefore to copy a galvanographic plate with corrections, it must first receive a film of silver or platina, as has been described, (the surface having been previously cleansed with ether or with quick-lime carefully rubbed on with soft leather;) a relief of it is then to be made, which in its turn is to be coated with platina or silver; this is then to be painted afresh whenever necessary, or altered in any manner that is desired, and a second sunk plate is to be formed thereupon. This last plate upon its removal presents a pure copper surface, provided the relief was duly coated with platina or silver, and the energy of the current was of sufficient intensity. From the power of the current depends the facility with which the plates may be separated when the silver or platina is used, or whether, when neither of those substances are employed, the plates can be parted at all or not.

I have instituted many experiments upon this point. I weakened the current by laying a glass disc upon copper rods, so that the fluid could circulate above and beneath it, about half an inch above the copper plate; and I found that then the precipitation proceeded so tardily as not to give a metal of a serviceable quality. I next substituted a parchment frame for the glass plate. In this case the deposit was likewise slow, while the metal thrown down was brittle, and here and there the two plates adhered. I now brought the drum within half an inch of the base, and by this means obtained, generally speaking, a tough deposit of copper, sometimes however it was brittle; but the two plates could always be easily separated, and the smooth surfaces were always faithfully given. This I have had frequent occasion to notice. At the first formation of the deposit therefore, it is always advisable to bring the zinc tamborine near to the base, or in other words, to increase the energy of the current.

As some skins of parchment, *cæteris paribus*, answer better than others for producing copper of an excellent quality, I always employ for the commencement of the deposit, a skin which I find by experiment to possess this property, and when the process has proceeded for a certain time, I substitute an inferior tamborine.

In giving the above mentioned film of platina or silver, the plates may be taken out of the liquor several times, dried, gently rubbed with leather, and again inserted into the fluid. The process will be successful, provided the plates are not left very much too long in either of the salt mixtures mentioned, and unless, in the case of platinizing the plates, too much of the platina solution should be used.

Common copper will seldom take this film as perfectly as galvanic copper does, and on many plates apparently pure, there are brought out patterns similar to those on what are termed watered ribbons.

It is superfluous to remark, that copper plates coated as above described with platina or silver, may be employed as a base for the reception of the picture in place of a silvered plate, and copper plates formed by galvanism are the best for this purpose.

From what has been said, it is evident that the cost of the apparatus for forming galvanographic plates, is but moderate. For producing one pound of galvanic copper, four pounds of sulphate

of copper are required, and about seventeen and one quarter ounces of zinc are converted into the sulphate.

Description of the Apparatus, with figures.

Fig. 1. Tamborine with its wooden hoop; the three feet on which it rests are to be cut out in such a manner that the air can escape from beneath the parchment on the apparatus being let down into the fluid.

Fig. 1.

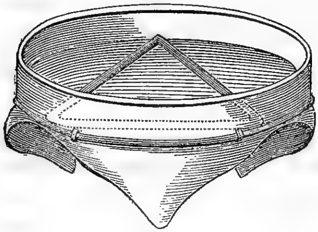


Fig. 2.

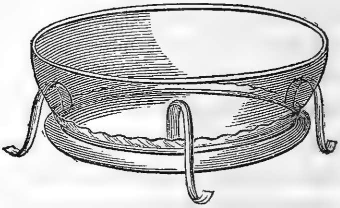


Fig. 3.

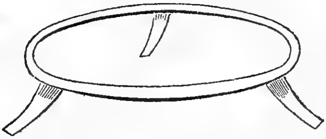


Fig. 6.

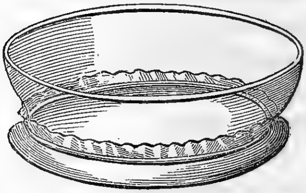


Fig. 2 and figure 6. Sugar basins with the bottom cut off, and having parchment or ox bladders stretched across the aperture thus made. They are either supported on wire legs, as fig. 2, or rest upon a tripod, like fig. 3, covered with a non-conducting substance, for instance a coat of melted wax.

Fig. 4.

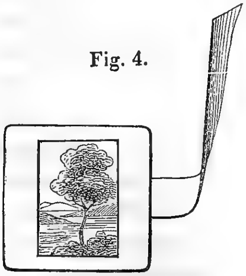


Fig. 5.

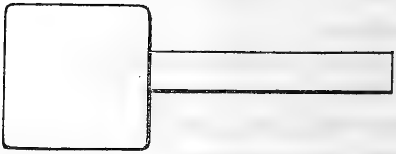


Fig. 4 and figure 5, the copper base-plate upon which the painted plate is laid.

Fig. 7, the leaden disc which is laid on the plate of zinc; the strip proceeding from the disc is to be connected with the strip proceeding from the base, fig. 4, by the application of the binding screw shown in fig. 8.

Fig. 7.

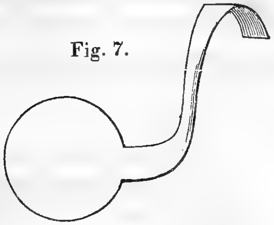


Fig. 8.

Fig. 9, a glass rod bent so as to form a triangle to be laid upon the membrane forming the tamborine. It is on this triangle that the zinc plate rests. For heavy zinc plates, a hooked support of copper wire, as shown in fig. 10, is to be used. This wire support may be coated with wax.

Fig. 9.

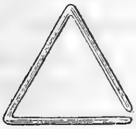


Fig. 10.

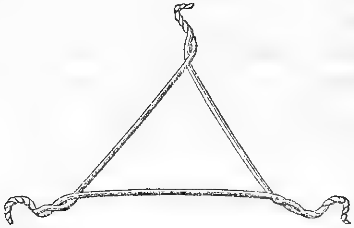
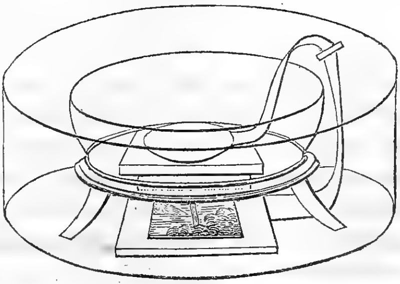


Fig. 11, a pair of copper or iron pincers for removing the plates from the cupreous solution.

Fig. 11.

Fig. 12 and figure 13, show the apparatus when the circuit is closed; *aa* is the base-plate, fig. 4; *bb* the painted plate; the tamborine is shown above, in which *cc* the glass triangle, *dd* the zinc plate, and *e* the leaden disc, are seen above each other; the

Fig. 12.



leaden disc is shown in connection with the base-plate by means of the binding screw, *o*; *k* indicates the height of the cupreous solution, and *z* that of the exciting fluid in the tamborine.

Fig. 13.

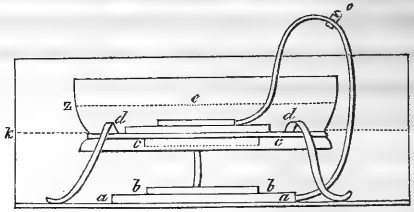


Fig. 14.

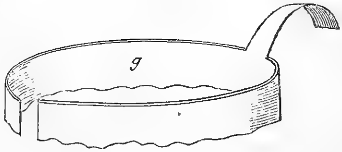
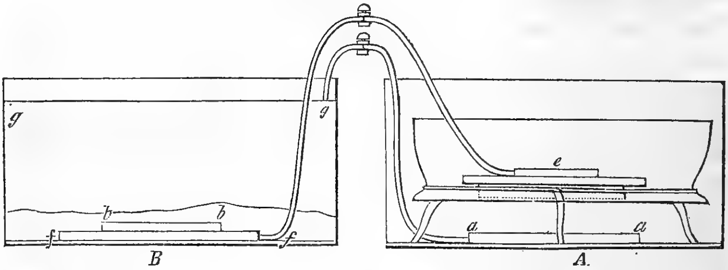


Fig. 15 represents a decomposing-cell apparatus. The copper plate *aa* in the vessel with the tamborine A, is connected by means of the strip with the copper plate *gg* of the vessel B, (fig. 15.) The leaden disc *e* is connected by a metal strip with the copper plate *ff* of the vessel B, and upon this latter plate lies the painted plate *bb*. In this arrangement the copper plate *gg* is taken up and consumed in the same ratio that copper is deposited upon *bb*, and upon the parts of *ff* not insulated by a coat of wax.

Fig. 15.



The sulphate of copper in the vessel A, undergoes decomposition at the same time, and *aa* becomes coated with a galvanic deposit of that metal. Two painted plates, one lying on *aa* and one on *ff*, may therefore be coated simultaneously; but the action proceeds much more slowly when this decomposing cell is employed, than when we have recourse to the apparatus represented in fig. 13. In using this arrangement, care must be taken that the plate *ff* is not in contact with the surrounding copper plate *gg*.

ART. II.—*Remarks made by* DR. HARE, *at a late meeting of the American Philosophical Society, on a recent speculation by Faraday on electric conduction and the nature of matter;*—communicated by the Author.

Philadelphia, Nov. 30, 1844.

Messrs. Editors—At the last meeting of the American Philosophical Society, I made some verbal remarks on a recent "speculation" of the celebrated Faraday, published in the London and Edinburgh Philosophical Magazine for February last. Of course a brief notice will be given of those remarks in the bulletin of the Proceedings. I send you for publication a statement of my reasoning on the questions at issue, hoping that it will not be found unworthy of the attention of philosophical chemists.

Your friend, ROBERT HARE.

Faraday objects to the Newtonian idea of an atom, being associated with combining ratios. These he conceives to have been more advantageously designated as chemical equivalents.*

This sagacious investigator adverts to the fact that after each atom in a mass of the metal potassium, has combined with an atom of oxygen and an atom of water, forming thus a hydrated oxide, the resulting aggregate occupies much less space than its metallic ingredient previously occupied; so that taking equal bulks of the hydrate and of potassium, there will be in the metal only four hundred and thirty metallic atoms, while in the hydrate there will be seven hundred such atoms. And in the latter, besides the seven hundred atoms, there will be an equal number of aqueous and oxygenous atoms, in all two thousand eight hundred ponderable atoms. It follows that if the atoms of potassium are to be considered as minute impenetrable particles, kept at certain distances by an equilibrium of forces, there must be, in a mass of potassium, vastly more space than matter. Moreover, it is the space alone that can be continuous. The non-contiguous material atoms cannot form a continuous mass. Consequently the well known power of potassium to conduct electricity must be a quality of the continuous empty space, which

* See his speculations touching electric conduction and the nature of matter, Vol. 24, 3d series, Philosophical Magazine and Journal, February, 1844.

it comprises, not of the discontinuous particles of matter with which that space is regularly interspersed. It is in the next place urged that while, agreeably to these considerations, space is shown to be a conductor, there are considerations equally tending to prove it to be a non-conductor; since in certain non-conducting bodies, such as resins, there must be nearly as much vacant space as in potassium. Hence the supposition that atoms are minute impenetrable particles, involves the necessity of considering empty space as a conductor in metals and as a non-conductor in resins, and of course in sulphur and other electrics. This is considered as a *reductio ad absurdum.* To avoid this contradiction, Faraday supposes that atoms are not minute impenetrable bodies, but, existing throughout the whole space in which their properties are observed, may penetrate each other. Consistently, although the atoms of potassium pervade the whole space which they apparently occupy, the entrance into that space of an equivalent number of atoms of oxygen and water, in consequence of some reciprocal reaction, causes a contraction in the boundaries by which the combination thus formed is inclosed. This is an original and interesting view of this subject, well worthy of the contemplation of chemical philosophers.

But upon these premises Faraday has ventured on some inferences which, upon various accounts, appear to me unwarrantable. I agree that "*a*" representing a particle of matter and "*m*" representing its properties, it is only with "*m*" that we have any acquaintance, the existence of *a* resting merely on an inference. Heretofore I have often appealed to this fact, in order to show that the evidence both of ponderable and imponderable matter is of the same kind precisely: the existence of properties which can only be accounted for by inferring the existence of an appropriate matter to which those properties appertain. Yet I cannot concur in the idea that because it is only with "*m*" that we are acquainted, the existence of *a* must not be inferred; so that bodies are to be considered as constituted of their materialized powers. I use the word materialized, because it is fully admitted by Faraday, that by dispensing with an impenetrable atom "*a*," we do not get rid of the idea of matter, but have to imagine each atom as existing throughout the whole sphere of its force, instead of being condensed about the centre. This seems to follow from the following language.

"*The view now stated of the constitution of matter, would seem to involve necessarily the conclusion that matter fills all space, or at least the space to which gravitation extends, including the sun and its system, for gravitation is a property of matter, dependent on a certain force, and it is this force which constitutes matter.*"

Literally this paragraph seems to convey the impression, that agreeably to the new idea of matter, the sun and his planets are not distinct bodies, but consist of certain material powers reciprocally penetrating each other, and pervading a space larger than that comprised within the orbit of Uranus. We do not live upon, but within the matter of which the earth is constituted, or rather within a mixture of all the solar and planetary matter belonging to our solar system. I cannot conceive that the sagacious author seriously intended to sanction any notion involving these consequences. I shall assume, therefore, that, excepting the case of gravitation, his new idea of matter was intended to be restricted to those powers which display themselves within masses at insensible distances, and shall proceed to state the objections which seem to exist against the new idea as associated with those powers.

Evidently the arguments of Faraday against the existence, in potassium and other masses of matter, of impenetrable atoms endowed with cohesion, chemical affinity, momentum, and gravitation, rest upon the inference that in metals there is nothing to perform the part of an electrical conductor besides continuous empty space. This illustrious philosopher has heretofore appeared to be disinclined to admit the existence of any matter devoid of ponderability. The main object of certain letters which I addressed to him, was to prove that the phenomena of induction could not, as he had represented, be an "*action*" of ponderable atoms, but, on the contrary, must be considered as an *affection* of them consequent to the intervention of an imponderable matter, without which the phenomena of electricity would be inexplicable. This disinclination to the admission of an imponderable electrical cause, has been the more remarkable, as his researches have not only proved the existence of prodigious electrical power in metals, but likewise, that it is evolved during chemico-electric reaction, in equivalent proportion to the quantity of ponderable matter decomposed or combined.

According to his researches, a grain of water by electrolytic reaction with four grains of zinc, evolves as much electricity as would charge fifteen millions of square feet of coated glass. But in addition to the proofs of the existence of electrical powers in metals thus furnished, it is demonstrated that this power must be inseparably associated with metals, by the well known fact, that in the magneto-electric machine, an apparatus which we owe to his genius and the mechanical ingenuity of Pixii and Saxton, a coil of wire being subjected to the inductive influence of a magnet, is capable of furnishing, within the circuit which it forms, all the phenomena of an electrical current, whether of ignition, shock, or electrolysis.

The existence in metals of an enormous calorific power must be evident from the heat evolved by mere hammering. It is well known, that by a skillful application of the hammer, a piece of iron may be ignited. To what other cause than their inherent calorific power can the ignition of metals by a discharge of statical electricity be ascribed?

It follows that the existence of an immense calorific and electrical power is undeniable. The materiality of these powers, or of their cause, is all that has been questionable. But, according to the speculations of Faraday, all the powers of matter are material; not only the calorific and electrical powers are thus to be considered, but likewise the powers of cohesion, chemical affinity, inertia and gravitation, while *of all these material powers only the latter can be ponderable!!!*

Thus a disinclination on the part of this distinguished investigator to admit the existence of one or two imponderable principles, has led him into speculations involving the existence of a much greater number. But if the calorific and electrical powers of matter be material, and if such enormous quantities exist in potassium, as well as in zinc and all other metals, so much of the reasoning in question as is founded on the vacuity of the space between the metallic atoms, is really groundless.

Although the space occupied by the hydrated oxide of potassium comprises two thousand eight hundred ponderable atoms, while that occupied by an equal mass of the metal, comprises only four hundred and thirty, there may be in the latter proportionably as much more of the material powers of heat and electricity, as there is less of matter endowed with ponderability.

Thus while assuming the existence of fewer imponderable causes than the celebrated author of the speculation has himself proposed, we explain the conducting power of metals, without being under the necessity of attributing to void space the property of electrical conduction. Moreover, I consider it quite consistent to suppose that the presence of the material power of electricity is indispensable to electrical conduction, and that diversities in this faculty are due to the proportion of that material power present, and the mode of its association with other matter. The immense superiority of metals, as conductors, will be explained by referring it to their being peculiarly replete with the material powers of heat and electricity.

Hence Faraday's suggestions respecting the materiality of what has heretofore been designated as the properties of bodies, furnish the means of refuting his arguments against the existence of ponderable impenetrable atoms as the basis of cohesion, chemical affinity, momentum and gravitation.

But I will in the next place prove, that his suggestions not only furnish an answer to his objections to the views in this respect heretofore entertained, but are likewise pregnant with consequences directly inconsistent with the view of the subject which he has recently presented.

I have said that of all the powers of matter which are, according to Faraday's speculations, to be deemed material, gravitation alone can be ponderable. Since gravitation, in common with every power heretofore attributed to impenetrable particles, must be a matter independently pervading the space throughout which it is perceived, by what tie is it indissolubly attached to the rest? It cannot be pretended that either of the powers is the property of another. Each of them is an m, and cannot play the part of an a, not only because an m cannot be an a, but because no a can exist. Nor can it be advanced that they are the same power, since chemical affinity and cohesion act only at insensible distances, while gravitation acts at any and every distance, with forces inversely as their squares: and, moreover, the power of chemical affinity is not commensurate with that of gravitation. One part by weight of hydrogen has a greater affinity universally for any other element, than two hundred parts of gold. By what means then are cohesion, chemical affinity, and gravitation, inseparably associated, in all the ponderable elements of matter? Is

it not fatal to the validity of the highly ingenious and interesting deductions of Faraday, that they are thus shown to be utterly incompetent to explain the inseparable association of cohesion, chemical affinity and inertia with gravitation; while the existence of a vacuity between Newtonian atoms, mainly relied upon as the basis of an argument against their existence, is shown to be inconsistent both with the ingenious speculation, which has called forth these remarks, and those Herculean "researches" which must perpetuate his fame.

Art. III.—*On the Zinc Mines of Franklin, Sussex County, New Jersey*; by Francis Alger, Member of the American Academy, of the Society of Natural History, &c. Boston.

Mineralogists need not be told of the great variety and richness of the mineral productions of Sussex County, N. J., as the published memoirs of Gibbs, Nuttall, Vanuxem, Troost and others, have already made these productions familiar to them, and their own cabinets bear ample testimony to the fact. It is my present intention, not to speak of these except incidentally, but to call the attention of mineralogists, and the public generally, to the valuable and extensive zinc mines of this district. Some recent observations, founded on explorations made with the view of working the ore, have enabled me to speak with more certainty on this subject; and I shall endeavor, as briefly as possible, to state the principal facts which have come under my notice. It should be remarked, in the first place, that the zinc of Sussex County, has been a subject of historical notoriety for the last seventy years. The property purchased by Lord Sterling, comprised all the mines of valuable metals that might be discovered; but it does not seem certain that its value was at all appreciated by him, or that he had any knowledge even of the existence of zinc in the ore. We have good evidence that large quantities of what is now known as the red oxide of zinc were shipped to England to be smelted for copper, under the impression of its being the common red oxide of copper. The openings from which it was then taken, now remain, and they evince but little judgment in mining operations. But whether the ore was ever reduced, we have no certain knowledge; we only know that the

operations were soon abandoned, and that, until within the last few years, no attempts have been made to resume them, or to discover any method of reducing the ore. We should except, perhaps, the few attempts made at the iron works at Franklin; but these were made principally with the view of obtaining the iron from the Franklinite, with which the red oxide of zinc is largely mixed. They failed in both respects, and the effect was disastrous. The zinc escaped in the form of white oxide, carrying off so much heat as to cause the furnace to "chill up," while the but partially deoxidized iron remained in an almost immovable mass at the bottom of the furnace. The clear-sighted Dr. Bruce, of New York, was the first writer who called the attention of the public to the importance of these zinc mines, and he plainly foresaw that they would some day develope vast resources to the country. We are also indebted to him for the earliest analysis of the ore, which was soon afterwards confirmed by M. Berthier, of France.*

As the manufacturing of pure zinc metal has become of great importance, from its increased consumption in the arts and manufactures of our country, enterprising individuals have turned their attention to the subject; and the discovery of extensive deposits of zinc ore has been looked for with great interest. Various mines have been called into notice, and some of them have been thought of sufficient extent for profitable exploration; but as they have proved to yield nothing but the common sulphuret of zinc, which requires a long and expensive process in its reduction, no company has ventured to engage in the business, and we are now entirely dependent on foreign countries for our supply of this metal.† At the Cornwall mines, in Great Britain, where it is well known, sulphuret of zinc is found to considerable extent, with calamine, or carbonate of zinc, this ore, as we are informed by De la Beche, is thrown away, because it cannot be employed to any profit.‡ Now these facts give great value to an ore which is known to contain no sulphur, to the extrication of which the

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* See Bruce's Mineralogical Journal, Vol. I, p. 96, where he has described these zinc ores, and given at length the *modus operandi* of his analysis of the red oxide.

† This now comes principally from Belgium, where the annual product is about 1,800 tons, and from the British isles, (mostly obtained from the carbonate,) where it amounts to 2,000 tons. Russia and Poland produce about 4,000 tons annually.

‡ Reports on Cornwall, Devon and West Somerset, pp. 337, 617. If it cannot be profitably worked in Cornwall, where labor is so cheap, why should we expect a more favorable result in this country?

chief difficulty is owing in the smelting process. In working the zinc ore of Sussex County, the only substance to be driven off is oxygen, and this is now effected by a very easy method in common cast-iron vessels, requiring only care, and attention to a few first principles in chemistry and metallurgy. Its reduction by the ordinary process of sublimation, *per descensum*, has proved but partially successful, owing to the imperfect methods adopted; but the late Mr. Hassler, of Washington, obtained it in a very pure state in this manner, and employed it in the fabrication of the beautiful weights and measures which he made for the United States government. At the same time, Mr. Ballou, of Franklin, was prosecuting his experiments, and obtained the metal in a pure state, while he employed the white oxide, or flowers of zinc, as a substitute for lead paint. Within the last year, a company in Boston has become largely interested in these zinc ores, and has instituted experiments which show that the metal can be profitably obtained in the manner already mentioned. A conditional offer of the whole property has been made to a French company, who have also satisfied themselves of the practicability of separating the metal in a large way; and this company, through the agency of a practical mining engineer and metallurgist, Mr. Hitz, is now engaged in exploring the mine more extensively, before accepting the terms of the offer. The old openings, made in Lord Sterling's time, afford but little means of judging of the nature or extent of the ore, as they were made without any true knowledge of the subject of mining; some of them even penetrate the limestone in a contrary direction to the dip and line of bearing of the metalliferous beds, which are remarkably uniform in their course. They are perpendicular shafts sunk from fifteen to twenty feet into the limestone, and some have supposed that silver has been obtained from them and carried to Europe; but, on removing the rubbish that had been thrown out, and enlarging one of them (at Sterling) for several feet in a horizontal direction towards the zinc, there were occasionally seen a few small particles of galena, with flakes of graphite, and stains of carbonate of copper. We have thus no reason to suppose that any silver was ever found, though it may have been the thing sought for by the earlier explorers.*

* The date of these openings is not recorded, so far as I know, nor does the fact, that pines and cedars more than fifteen inches in diameter, have grown up on the edges of them, give us much clue to it.

I have said that the beds of zinc ore are remarkably uniform in their course. Of this the reader will get a better idea by a few words in reference to the topography of this district. The Wallkill valley, which extends nearly north and south through Sussex County, has its eastern limits bounded by a continued series of elevations known as the Hamburg or Wallkill mountains, and composed of granite or gneiss; while, towards the southern limits of this valley, we have a less elevated range of hills, commencing near Sparta, and extending through Sterling to Franklin, and composed principally of granular limestone. This range, which also extends nearly north and south, is the great repository of the mineral wealth of Sussex County. It abounds in all the beautiful crystallized minerals for which the place has so long been celebrated, and is prolific in ores of iron, as well as of zinc. In the variety and richness of its productions, it is scarcely less noted than Utön or Arendal in Europe. A fine river passes through this valley, affording ample water-power for pounding, washing and smelting the ores, while the neighboring hills are covered with a luxuriant forest for supplying charcoal. The zinc ore beds extend about four miles; they are not found north of Franklin, nor south of Sterling, though loose masses, or bowlders, are abundantly scattered over the surface of the ground, or imbedded in alluvium and gravel, at various places in a north or northwest direction; and these were obviously transported by the same denuding current to which the various drift of this country is now referred. The occurrence of these masses, in considerable abundance, has led many who are not conversant with such phenomena, to suppose the existence near by of large deposits *in situ*. But I am convinced, from the observations of Prof. Rogers, as well as from my own examination, that all such hopes will be disappointed; for although the same limestone, without any essential change in its character, extends for several miles to the south of Sterling, and as far north as Orange County, in New York, it is no where found to exhibit a trace of zinc, excepting in the form of transported bowlders; and even these are not found *north* of Franklin. The fact that a small portion of zinc (probably in the state of carbonate) is found in the hematite iron ore, three miles south of Franklin, has no bearing in the case, because the hematite ore at other places, as in New York and Massachusetts, is known to contain this metal. We may there-

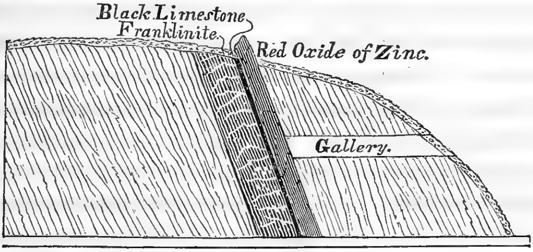
fore affirm that the only deposit of oxide of zinc at present known to mineralogists, is in Sussex County, and is there circumscribed by the limits above stated. At Sterling, the ore beds appear on the east flank of the limestone hills, while at Franklin, four miles to the north, they are on the west side,—the great belt of the limestone, as it extends through the valley in this direction, being thrown considerably to the east of the line of its direct prolongation at Sterling, while the same relations, as to the order of occurrence, are observed between the beds of zinc and the rock at both places, as well as at all the intermediate points where they have been penetrated. The strata of limestone run nearly northwest and southeast, dipping at an inclination from the vertical, 70° to 80° to the eastward. The direction and dip correspond here with the strata of gneiss, though deviating in other places, by causes of paroxysmal action, which have intruded masses of gneiss through the limestone, and destroyed its continuity of stratification; sometimes forming a blended mass of both materials, and including large and shapeless deposits of magnetic iron ore. This rock is the *altered limestone** of Prof. Rogers, who has most ably treated of the various phenomena relating to it, in his report on the Geology of New Jersey, to which the reader is referred.

I remark, that the relations between the beds of ore and the rock are always the same; and here I would not have it understood that there are several *disconnected* and parallel beds of zinc ore, regularly interstratified with the limestone beds, but that there is, in fact, only *one* bed—this being made up of *three* continuous parallel divisions. When we have penetrated the outcrop of limestone at Sterling, on the east side of the hill, we first come to an outer belt of from three to seven feet in thickness, consisting of nearly equal parts in bulk, of red oxide of zinc and Franklinite.† Second, in close contact with the mixed ore, but no where blended with it, we meet with a thin seam of brownish-black fer-

* A member of the lower secondary, or Apalachian rocks, of Prof. Rogers. It presents great diversity of aspect and composition, but has never been found to contain fossils when in close proximity with the intruded igneous dykes and beds. In fact, the fossiliferous character of this limestone is shown only in one or two very remote patches, pointed out by Prof. Rogers, which thus derive great interest by characterizing the whole formation.

† The actual proportion, by weight, as determined by pulverizing a quantity, and carefully separating one from the other by a magnet, I found to be a little over 60 per cent. of red oxide.

ruginous limestone, very heavy, but easily disintegrating, being a coarse crystalline variety; this is from two to six inches thick. Third, we reach a bed of pure Franklinite, more or less crystallized, sometimes perfectly so, either in the cavities, or at the line of junction with the ferruginous limestone,—the limestone being no more united with the Franklinite than it is with the mixed materials of the first bed: this bed is from ten to twenty feet in thickness. Succeeding this, we have nothing but the contiguous gangue of limestone, until it reaches the gneiss farther to the westward. The following diagram represents a section of these beds at Sterling, near the horizontal gallery made by Mr. Hitz. The beds are not the widest at this place, but their position is the most favorable for observation and exploration.



Now at Franklin, as a proof of the singular regularity of these associated beds, the order is not reversed, though it appears to be. Our position is only reversed, and we see the beds from the west, instead of the east. Of course, the outer bed nearest to the valley, is the immense bed of pure Franklinite, the inner one being the mixed red oxide, thereby rendering the mining operations less favorable here than at Sterling.

The most singular feature in these beds (perhaps it is no where else in the world more conspicuous) is the beautiful and perfectly distinct separation observed between them, along the whole line of their contact. This circumstance renders it difficult to explain the origin of these deposits, either from infiltration above or injection beneath, unless we refer them to different epochs, and suppose a suspension or change in the cause which produced them, so that successive intrusions of the matter now filling the original opening, could have taken place. That one must have been deposited after the other, we are as certain as we are that one mineral vein which crosses another must be the newest. It is not my intention, however, to enter much into theory on this

most difficult subject, upon which geologists are so much divided in their views; but it seems to me, that the theory so ably supported by M. Necker* and others, that mineral deposits are the results of *sublimation*, is the most likely to be received. And it is a theory, moreover, which meets with a most ready application to ores of *zinc*, and particularly to the deposits of them at this place. At Sterling, the red oxide of zinc forms a prominent ridge, or wall, along the side of the hill, (as shown in the diagram,) considerably above the adjoining bed of pure Franklinite, appearing thus to have resisted the disintegrating process by which immense quantities of the Franklinite have been crumbled into a loose gravel, which so covers the ground as to destroy vegetation. This may be seen most conspicuously on a hill about fifty rods west of the principal opening, where we are presented with one vast, isolated mass, the origin of which I confess is not easy to be explained. This fact must, however, be stated, and it may have some bearing upon theory:—it is not accompanied by red oxide of zinc, and it presents none of the characters of a bed or vein, so far as I could discover. Is it a single isolated mass protruded up from beneath, or has it gradually filled up, by sublimation or aggregation, a once open space? Its occurrence is similar to the irregular beds of magnetic iron ore throughout this range, and the occurrence of gneiss in close proximity with it,—an invariable accompaniment of the limestone wherever it bears the ore,—seems to indicate a like origin for both the Franklinite and the iron ore; and it is remarkable, that when the limestone and gneiss have thus become blended, we then find the rock well sprinkled with various crystallized minerals, such as blue and green spinelle, red and black garnets, &c., the fused appearance of many of them fully attesting their igneous origin.

In conclusion, I have a few words to offer in regard to the economical or commercial value of these zinc mines. It must be understood that, although the Franklinite contains about 17 per cent. of oxide of zinc, it is of no importance as an ore for reduction; nor has it hitherto proved of any value as an ore of iron. The red oxide is all that is proposed to be worked. This, as I have intimated, does not occur in a pure state in masses of any

* See his paper in the Proceedings of the London Geological Society, Vol. I, p. 392; also Ansted's Treatise on Geology, Vol. II, pp. 271, *et seq.*

considerable size, fragments of two or three pounds being the largest. It forms a sort of paste, in which the crystals or grains of Franklinite have become imbedded, and it is required to be separated from the Franklinite by the process of burning, and pounding, and the use of magnets. Explorations at a greater depth must determine whether the proportion of the Franklinite or red oxide increases relatively with the depth of the mine. I know of nothing in relation to other mines, that can lead to any well founded opinion on this subject. If the red oxide should continue to form one half of the bulk of the bed, or even if it should not hold out so much at a greater depth, it will nevertheless prove immensely valuable for reduction, because the expense of separation by rotary magnets, including burning and pounding, will not exceed four dollars for each ton. Now, if we suppose the average proportion to be one half red oxide, we may form a tolerably correct idea of the quantity of *metallic* zinc within any given number of cubic feet of the beds at Franklin and Sterling, by ascertaining the weight of each cubic foot of ore, from its known specific gravity.

Taking the specific gravity of the red oxide at 5·420, we have 340 lbs. (very nearly) the weight of each cubic foot. One half of this is 170 lbs., or the quantity of red oxide in each cubic foot of the ore, as it averages. Oxide of zinc contains 81 per cent. of pure metal; consequently, 170 lbs. of the ore contain 137 lbs. pure metallic zinc.* The length of the bed visibly exposed at Sterling is more than six hundred feet; its depth we will assume to be one hundred feet, which will be as deep as it can be conveniently drained.† Its average width cannot be less than four feet. Now $600 \times 4 \times 100 = 240{,}000$ cubic feet of ore, each of which contains 170 lbs. of red oxide. Again, $240{,}000 \times 170 = 40{,}800{,}000$ lbs. of red oxide, which, yielding 81 per cent. of pure metal, gives of it, 33,048,000 lbs.‡ This, multiplied by six cents,

* I am aware that I do not here take into account the portion of manganese and iron combined with the red oxide, but the proportion of red oxide in what appeared to be an average sample of the ore, after the Franklinite had been separated by the magnet, amounted to considerably over one half of the whole bulk.

† There can be no doubt that it is really co-extensive in depth with the limestone; and it probably penetrates deep into the substratum on which the limestone rests. The maximum thickness of the limestone is supposed by Prof. Rogers to be upwards of 2000 feet.

‡ This estimate supposes the whole cubic contents of the bed of red oxide, to be entirely without cavities; a character which it has thus far uniformly maintained.

the average market value of zinc, will give $1,982,880—the value of zinc within the limits mentioned. Nature has provided every local advantage that could be wished for the easy exploration of the mines; and embracing every expense preparatory to the reduction of the ore, including its reduction also, it is pretty well ascertained that the metal may be obtained in the large way at a cost not exceeding three cents per pound. Here, then, there would be a clear profit, deducting the cost of buildings and the expenses of transportation to market, of nearly $1,000,000. If we suppose the quantity of ore consumed daily to be ten tons, (a small estimate,) only five years will be required to work up the ore contained in the space mentioned.

Boston, September 1, 1844.

Mr. A. A. Hayes having, at my request, analyzed a portion of a very pure specimen of the foliated red oxide of zinc, I here subjoin his results, with his communication to me on the subject. The original specimen weighed about three pounds, and consisted of very brilliant horizontal layers, some of them about one eighth of an inch in thickness. It affords perfect cleavage planes, and the small fragments thus detached are translucent, and of a deep garnet-red color. The horizontal layers are disposed upon each other in a position or direction parallel with the deeply inclined walls of the bed, as if they were deposited by a gradual condensation of metallic vapor rising up from the deep and intensely heated chasm beneath. This view of its origin is supported by what we sometimes witness in smelting furnaces, (like those for obtaining pig iron,) where the ores employed contain portions of zinc. We find massive coatings of oxide of zinc lining the upper parts of the furnace, where the temperature became reduced so as to admit of its condensation. Fine examples of this may be seen at the furnace in West Stockbridge, Mass.; the zinc here originating from brown hematitic iron ore. Mitscherlich has recorded more remarkable instances of the production of regular crystals of *red oxide of zinc*, identical with the mineral here described. These were noticed by him in some of the furnaces of Konigshutte, in Silesia.

I would observe that Mr. Hayes's analysis has established two important facts, which are contrary to the views hitherto held in relation to this mineral; first, that the deep red color is *not* owing

to the presence of manganese; and second, that this metal does *not* exist as red oxide, (a double oxide consisting of single equivalents of protoxide $\dot{Mn}$, and deutoxide $\dddot{\mathbf{Mn}}$,) but simply as protoxide. He has shown that the red color is owing to the peroxide of iron, aided, as he believes, by the molecular arrangement of the particles, when the color is in the greatest intensity.

The various examinations tend to show that the oxides of iron and manganese do not constitute definite atomic proportions in the mineral, but exist in unequal distribution. Its composition is therefore to be expressed simply as $\dot{Zn}$, mixed with $\dot{Mn}$, and $\dddot{\mathbf{Fe}}$. Berthier's results approach very nearly to atomic proportions,* but Berzelius and Rammelsberg, in citing both Berthier's and Bruce's analyses, have given no formula. The formula given by Kobell and Plattner,† who suppose the manganese to exist in the mineral as red oxide, is of course no longer correct.

Analysis of Red Oxide of Zinc.

The specimens examined presented masses, made up of parallel folia, each about one fortieth of an inch in thickness. A slight white coating invested their surfaces in spots; generally they were covered by a thin covering, composed of minute scales of specular oxide of iron, giving a dark brown color by refracted light. After removing the ferruginous coating, the surfaces exhibited a red color. When fractured across the folia, or reduced to a coarse powder, the color was a pure garnet red; thin portions, being transparent, emitted red light. Not crystalline; the arrangement of the parts was that of a sublimate. The fine powder has a light orange yellow color. After carefully expelling air from a mass, its specific gravity was 5·524.

Water boiled on the powder gives traces of sulphates and hydrochlorates in minute quantity. Diluted nitric, acetic and sulphuric acids, dissolve the fine powder, without the aid of heat; no gas is disengaged, and some minute scales of specular oxide of iron alone remain. These scales remain for some time suspended in the diluted solutions, and, besides rendering them tur-

* See Phillips's Mineralogy, Am. edition, p. 565.

† Plattner on the Use of the Blowpipe, trans. by Muspratt, p. 142.

bid, give a dull brown color; the filtered solutions are colorless and transparent. The diluted nitric solution, with red prussiate of potash, gives no blue color, while the yellow prussiate produces a blue precipitate, like that of peroxide of iron in a solution of salt of zinc. The addition of carbonate of lime to the nitric solution occasions the separation of peroxide of iron, without removing any peroxide of manganese. When hydrochloric acid is used for effecting solution of the powder, the cold acid exhibits a slight yellow tint; no brown color produced by peroxide of manganese appears; a solution of muriate of ammonia, aided by heat, dissolves the powder, ammonia being disengaged, and the scales of specular oxide of iron form the only residue.

By heat, the color of the powder becomes darker, and finally brown; on cooling, the powder becomes of a dull ochre yellow. Acids indicate that a change of composition has resulted from heating; a separation of peroxide of manganese attending the solution in cold diluted acids.

These trials prove that the oxide of manganese in this mineral is in the state *of protoxide*, and that the orange color of the powder is probably due to the presence of peroxide of iron, having the same high coloring power which it exhibits in some double salts. The beautiful garnet red color of the mineral is doubtless due to the molecular arrangement of the particles—an effect more strongly marked than it appears in the Siberian red lead ore, but a less considerable change than is exhibited by the biniodide of mercury or the thionurate of lead.

Solutions of the powder contained oxides of zinc, manganese and iron, with a minute quantity of silica; no other substances could be detected.

Analysis.—50 grs. of the powdered mineral, which had been dried at 150° F., lost at a higher temperature 0·125 of water, containing organic matter.

50 grs. of the same powder were dissolved in nitric acid, contained in a covered vessel; by evaporation at a low temperature, a saline mass was obtained. Exposed to a gradually increasing temperature, until red hot, a brown colored residue was left, which, when cold, weighed 50·275. Another quantity of nitric acid was evaporated from it, and a higher temperature employed, without changing the weight. The manganese oxide exhibited the action with acids, which characterizes the red oxide state.

I. 50 grs. of the powder were dissolved in diluted nitric acid, excepting some light scales, without the application of heat. The undissolved parts, separated by a filter, were dried ; their weight was 0·220. When decomposed by a mixture of nitric and hydrochloric acids, a clear yellow solution was obtained, in which an excess of pure ammonia gave a red brown oxide, free from manganese, and having the characters of peroxide of iron. The ammoniacal solution contained neither oxide of zinc or manganese.

II. By slowly evaporating the fluids produced by washing the insoluble part with the nitric solution, an excess of nitric acid was removed. The saline mass was not wholly soluble in water, peroxide of manganese remaining. The fluid, rendered acid with nitric acid, was boiled on the peroxide of manganese, and, while warm, a slight excess of chlorite of potash was added, to precipitate all the oxides. When cold, the fluid was diluted, and treated with nitric acid in a dilute state, until after the escape of chlorine an acid fluid was obtained. A brown bulky oxide remained undissolved, which was readily separated by a filter, and washed in boiling water. Dried and heated to a bright redness for some time, there remained 3·212 grs.

The brown oxide, in hydrochloric acid, gave chlorine and dissolved, affording a yellow solution ; rendered neutral by ammonia, and mixed with a solution of succinate of ammonia, a precipitate was obtained, which, by calcination with nitric acid, gave 0·180 of peroxide of iron. The manganese solution was oxidized by chlorite of potash, and warmed in a solution of ammonia, no oxide of zinc could be detected.

III. The solution and washings from the brown oxides of II, were evaporated, and alkaline chlorite of potash added, till a small precipitate was produced ; by boiling the fluid on the precipitate, the white color of the latter was unaltered. Carbonate of potash in excess was added to the liquor, and the whole evaporated to a paste. Boiling pure water left a snow white carbonate undissolved, which was washed on a filter. The fluid from the carbonate, with the washings, were mixed with hydrosulphate of ammonia; a trifling precipitate of a white color was obtained, which was calcined, dissolved in nitric acid, the solution mixed with a boiling solution of carbonate of potash, and the minute quantity of carbonate added to that on the filter. The carbo-

nate was ignited so long as heat occasioned any loss of weight; there remained 46·741 of oxide of zinc. This oxide was soluble in sulphuric acid, and the resulting sulphate remained white, when the excess of sulphuric acid was expelled by heat.

50 parts have thus afforded of

Oxide of zinc, (III,)	46·741
Red oxide of manganese, (II,) . .	3·032
Red oxide of iron, (II,)	0·180
Scales of specular iron, ...	0·220
	50·173

50 grs. of the fine powder had remained in a dessiccated atmosphere some days, without change of weight. A flask, nearly filled with muriatic acid, in which a slip of pure copper had been boiled half an hour, was closely stopped, after introducing the bright weighed slip with the powder. Placed in a bath at 120° for twelve hours, the powder was dissolved completely. The weighed slip of copper had lost 0·840, indicating the addition of only 0·105 of oxygen; a weight corresponding nearly to that of the oxygen in the neck of the flask, above the acid fluid.

The excess of weight, which the analysis has given, is therefore due to oxidation of the manganese, in a higher degree than that in which it exists in the mineral. The calcined mineral gained 0·275 on 50, besides losing by the first effect of heat 0·125 moisture. Considering the oxide of manganese as a protoxide in the mineral, 100 parts contain—

Oxide of zinc, ...	93·482
Protoxide of manganese, . . .	5·500
Peroxide of iron, ...	·360
Scales of specular iron, . . .	·440
	99·782

I have made several analyses, by different processes, operating on different fragments of this mineral, and when the oxides were perfectly separated from each other, in no instance has the red oxide of manganese exceeded 6·40 in 100 of the weight.

A. A. Hayes.

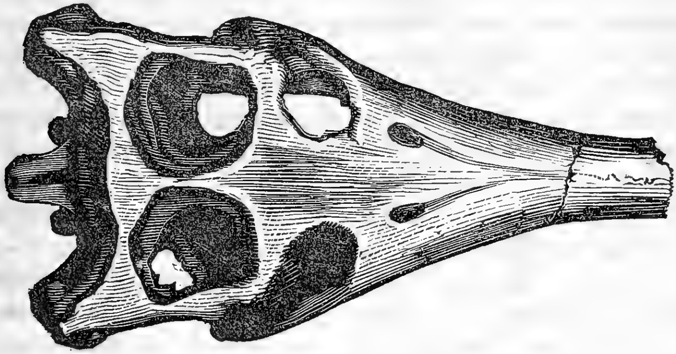
Roxbury Laboratory, November 20, 1844.

Art. IV.—*Description of the Head of a Fossil Crocodile from the Cretaceous Strata of New Jersey;* by Samuel George Morton, M. D.*

[From the Proceedings of the Academy of Natural Sciences of Philadelphia, for August, 1844.]

Crocodilus (Gavialis?) *clavirostris.*

Skull very broad posteriorly, whence it tapers in a gradual and triangular manner to a narrow, elongated snout. Orbits very large, oblique, and with but slight marginal elevation. Temporal fossæ of great size, and the spiracles? placed immediately below and before the inner margin of the orbit. Length of the head from the superior margin of the occiput to the broken end of the snout 23 inches; width of the occiput behind, 12½ inches; lateral diameter of the orbit 3½ inches; lateral diameter of temporal fossæ 4½ inches. Remaining teeth 13 on each side. Lateral diameter of terminal end of the snout 3¼ inches.



This species is wholly unlike any other, fossil or recent, with which I have been able to compare it. It seems to form an intermediate link between the Gavials and true Crocodiles, for the snout, though long and narrow, is gradually and not abruptly produced from the head, and has probably been from eight to twelve inches longer than it now is.

This remarkably large and admirably preserved relic, was found in the cretaceous limestone which overlies the ferruginous marl

* Communicated by the Author.

near Vincentown, in New Jersey, and has been obligingly presented to our Institution by General William Irick, (on whose farm it was discovered,) and William Whitman, Esq. of this city. These strata of cretaceous limestone were first discovered and announced by me in 1829; in which year I published an account of them, with a list of their organic remains, as observed at Timber Creek, in Gloucester County.* Since that period I have continued my researches into this interesting section of our geology, which I have subsequently identified in two other localities in New Jersey, viz. Vincentown and the vicinity of Salem, and perhaps also in South Carolina west of Charleston; at which latter place the fossils have been chiefly collected by Dr. Ravenel, who is preparing for publication a description of several species hitherto unknown.

I obtained from Timber Creek at my first visit, a fragment of the jaw of a Crocodile with three teeth; but the parts were not sufficiently perfect to enable me to decide to which division of this class of animals it pertained. Upon comparing it, however, with the specimen now under consideration, it appears to belong to a Gavial, and in all probability to the *G. clavirostris*.

Dr. Harlan, many years ago, described the remains of a fossil crocodile from the lower or ferruginous beds of this series.† These fragments enabled Dr. Harlan to reconstruct the head so far as to identify it as a true crocodile, to which he gave the name of *C. macrorhyncus*.‡ This species is figured in the fourth volume of the Journal of the Academy, and the fossil itself is preserved in the Society's collections.

During Mr. Lyell's recent visit to this country, he also obtained some fragments of a fossil crocodile which appear to belong to the Procælian division of this family.§

Prof. Buckland remarks, that "as there were scarcely any mammalia during the secondary periods, whilst the waters were abundantly stored with fishes, we might, *à priori*, expect that if any crocodilean forms had then existed, they would most nearly have resembled the modern Gavial. And we have hitherto found

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* Vide Journal of the Academy of Natural Sciences, Vol. VI.

† Journ. Acad. Nat. Sci. Vol. IV.

‡ Medical and Physical Researches, p. 369.

§ American Journal of Science, Vol. XLVII, p. 214.

only those genera which have elongated beaks in formations anterior to, and including the chalk; whilst true crocodiles, with a short and broad snout, like that of the cayman and alligator, appear for the first time in strata of the tertiary periods, in which the remains of mammalia abound."*

This observation would seem to differ in a geological sense, from that of Dr. Harlan, as just quoted, because his description and figure correspond to those of a true crocodile; while the *C. clavirostris* seems, as we have remarked, to possess an intermediate organic structure.

M. Geoffrey St. Hiliare has divided the fossil Gavials into two genera, viz. *Teleosaurus* and *Steneosaurus*, which chiefly differ from each other in the position and form of the anterior termination of the nasal canal. As the terminal portion of the snout of the present specimen has not been discovered, we cannot avail ourselves of this generic distinction; and this uncertainty must continue until the recovery of the deficient portion may enable us to decide the question.

The following list embraces all the organic remains hitherto discovered in New Jersey, in the same strata with the *Crocodilus clavirostris:* they are mostly described in the sixth and eighth volumes of the Society's Journal.

Squalus, several species; Belemnites? *ambiguus*, (M.); Planularia *cuneata*, (M.); Nautilus Dekayi? (M.); Scalaria annulata, (M.); Cirrus crotaloides, (M.); Vermetus rotula, (M.); Gryphæa vomer, (M.); Gryphæa convexa, (Say); Pinna rostriformis, (M.); Teredo tibialis, (M.); Cidarites diatretum, (M.); Cidaretes armiger, (M.); Nucleolites crucifer, (M.); Ananchytes cinctus, (M.); Ananchytes fimbriatus, (M.); Escharina sagena, (M.); Eschara digitata, (M.); Retepora ——, fragments; Anthophyllum (Montivaltia) atlanticum, (M.); Alveolites cepularis, (M.); Alcyonium ——, Idmonea contortilis, (*Lonsdale*); Alecto fascicularis, (*Lonsdale*); and Cellepora tubulata, (*Lam.*)

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* Bridgewater Treatise, Vol. I, p. 251, and Penny Cyclop., Art. Crocodile.

Art. V.—*Observations on a Second Series of Ancient Egyptian Crania;* by Samuel George Morton, M. D.

[From the Proceedings of the Academy of Natural Sciences of Philadelphia, for October, 1844.]

Towards the close of the year 1842, Dr. Lepsius, the distinguished head of the Prussian Scientific Commission in Egypt, reopened several very ancient tombs in the vicinity of the Pyramids of Ghizeh. These tombs date with the third and fourth dynasties of Egyptian chronology, as is proved by their inscriptions; but having been the receptacles of wealthy individuals, they were no doubt plundered in very remote times; and whenever succeeding generations have again devoted them to sepulchral purposes, avarice has renewed its desecrations in the search for treasure. Thus, the Hykshos, Persians, Greeks, Romans and Saracens, have probably each in turn violated these tombs; leaving it a question of entire uncertainty, whether the embalmed bodies now found in them belong to the earlier or later epochs of Egyptian history. I make these remarks to show that I do not infer the age of these mummies from the date of the tombs; but at the same time it may be observed, that in the mere search for plunder, there was no occasion to destroy or eject the bodies of the dead; and mutilated as they are, it is possible and even probable, that some of them pertained to a very remote age.

My friend Dr. Pickering, writing to me from Cairo about the time of these explorations, observes that Dr. Lepsius expected to find "the veritable remains of the primeval Egyptians; but it was discovered that they had been displaced by *Greeks*, &c., and that there was nothing of this sort older than Psammeticus." (B. C. 550.) The bodies that retained their legends may have been of Greek and other comparatively modern inhabitants of Egypt; but with respect to the seventeen skulls before us, I have no hesitation in declaring, that but two of them could have belonged to persons of Greek, or any other Indo-European lineage. The others may have borne Greek inscriptions, but that would not make them Greeks; for the language of the latter people was the compulsory vernacular tongue during most of the Ptolemaic epoch. Moreover, the skulls in question are entirely denuded of bandages and even of integuments; whence it seems

evident that no inferences drawn from Greek or other inscriptions could have applied to *them.*

The following is an ethnographic analysis of this series of crania:

Egyptian form, - - - - - -	11
Egyptian form, with traces of Negro lineage,	2
Negroid form, - - - - - -	1
Pelasgic form, - - - - - -	2
Semitic form, - - - - - -	1
	17

Remarks.

1. The *Egyptian* form is admirably characterized in eleven of these heads, and corresponds in every particular with the Nilotic physiognomy, as indicated by monumental and sepulchral evidences in my Crania Ægyptiaca, viz.—the small, long and narrow head, with a somewhat receding forehead, narrow and rather projecting face, and delicacy of the whole osteological structure. No hair remains, and the bony meatus of the ear corresponds with that of all other Caucasian nations.

Two other heads present some mixture of Negro lineage with the Egyptian, which is expressed in the conformation and expression of the facial bones, more particularly as seen in the greater breadth and flatness of the face, and a stronger development of the upper maxilla.

Of these thirteen crania, eleven are adult, of which the largest has an internal capacity of 93 cubic inches, and the smallest 76, giving a mean of 86 cubic inches for the size of the brain. This measurement exceeds, by only three cubic inches, the average derived from the entire series of *Egyptian* heads in my Crania Ægyptiaca.

The facial angle of the adult heads gives a mean of 82°, the largest rising as high as 86°, and the smallest being 78°. Two other heads are those of children, in whom the Egyptian conformation is perfect, and these give, respectively, the remarkably large facial angle of 89° and 91°. The mean adult angle is greater than that given by the large series measured in the Crania Ægyptiaca. Is this owing to the fact, that the heads now under consideration belonged to persons of distinction, and probably, therefore, of education and refinement?

These crania, as already observed, are long and narrow, and receding in front; but posteriorly, in the parietal regions, they become much broader; the whole occiput is very full, and remarkably projecting; the sides of the cranium are rather flat, and the coronal region long and depressed.

2. The *Negroid* head, as I have elsewhere explained, is a mixture of the Caucasian and Negro form, in which the latter *predominates.* Such is the case in the present instance, as even a partially practised eye can readily discover. This head strongly resembles those of two modern Copts in my possession. It gives 81 cubic inches for the size of the brain, and a facial angle of 80°. It is remarkable for deep depressions on the lateral surfaces of the parietal bones, apparently caused by the action of the posterior portions of a powerful occipito-frontalis muscle. Among six hundred skulls in my collection, but two present this development in an equal degree; one is an Egyptian, the other a Hindoo head.

3. Of the two *Pelasgic* heads, one is perfect, and well characterized in most of its proportions. It has an internal capacity of 93 cubic inches, and a facial angle of 80°. The other has lost the bones of the face, whence its ethnographic relations are not so obvious; but I have ventured to judge it by its cranial developments. It is internally but two cubic inches smaller than the other.

4. The solitary *Semitic* head, has rather the common Arab, than the Hebrew cast of features. It measures internally 87 cubic inches, and has a facial angle of 79°.

The ages of the individuals to whom these seventeen skulls pertained, may be proximately stated as follows: 5, 7,* 18, 20, 20, 25, 30, 40, 40, 40, 50, 50, 50, 50, 50, 50, 55.

The results derived from this series of crania, sustain in a most gratifying manner, those obtained from the greater collection of one hundred skulls sent me from Egypt, by my friend George R. Gliddon, Esq., and which have afforded the materials of my Crania Ægyptiaca; and without making further comparisons on the present occasion, (for I design from time to time to resume the subject, as facts and materials may come to my hands,) I shall merely subjoin my ethnographic table from the Crania Ægyptiaca, so extended as to embrace all the ancient Egyptian skulls now in my possession.

* The two juvenile heads are of course not used in calculating the *mean* either of the size of the brain or the facial angle.

Ethnographic Table of one hundred and seventeen ancient Egyptian Crania.

Sepulchral Localities.	No.	Egyptian.	Pelasgic.	Semitic.	Mixed.	Negroid.	Negro.	Idiot.
Memphis,	26	7	16	1	1	1		
Ghizeh,	17	11	2	1	2	1		
Maabdeh,	4	1	1			2		
Abydos,	4	2	1	1				
Thebes,	55	30	10	4	4	5		2
Ombos,	3	3						
Philæ,	4	2	1				1	
Debôd,	4	4						
	117	60	31	7	7	9	1	2

It remains for me to add, which I do with great pleasure, that I am indebted for this second series of Egyptian crania to Mr. Wm. A. Gliddon, of Cairo, who, prompted by that extraordinary interest in Egyptian questions which seems inherent in his family, has availed himself of every opportunity for extending our knowledge of the people and the monuments of the valley of the Nile.

Art. VI.—*Catalogue of the Shells of Connecticut;* by the late James H. Linsley.

The following catalogue of the shells of Connecticut, prepared for the Yale Natural History Society by the Rev. James H. Linsley, was left among the papers of the lamented compiler. The study of the conchology of his native State was his favorite pursuit, and to it he had devoted more time and investigation, than to any and all the other classes of zoology which have claimed his attention, and catalogues of which have successively appeared in the American Journal of Science, including the Mammalia, Birds, Reptiles, and Fishes of Connecticut.

He has more than doubled the number of shells supposed by naturalists three years since, to be resident in our State, and has also, it is believed, discovered many species entirely new.

For these reasons, we have presented this catalogue to the notice of the Society, though we very much regret that the many valuable and interesting notes, which under happier circumstances would have accompanied it, have not been left on record, and are therefore necessarily omitted.

The many kind attentions in the form of specimens, information respecting localities, &c., which Mr. Linsley received from

various gentlemen and naturalists, were duly appreciated and gratefully remembered, and would, in a different event, have been here cordially acknowledged.

CLASS V.

Annulata.

Annulata sedentaria.

Amphitritea.

1. Pectinaria Belgica, Lam., Stratford. Gould's Report on the Invertebrata of Massachusetts, fig. 1.

2. Sabellaria crassissima, Lam., Long Beach, Stratford. Dr. Jay's Catalogue, p. 6.

*3. Amphitrite ventilabrum, Lam., Long Beach, Stratford. Gould, p. 7.

Serpulea.

4. Spirorbis nautiloides, Lam., Stonington, on sea grass, &c. Gould, p. 8.

5. Spirorbis Spirillum, Lam., Stonington. Gould, p. 8.

6. Spirorbis sinistrorsa, Mont. sp., Gould, Stonington, on sea grass, rare. Gould, fig. 4.

*7. Serpula angulata, Dekay, Stratford.

*8. Serpula arenaria, Linn., Long Island Sound.

9. Serpula carinata, Nobis, Stonington, on *Mactra gigantea*, Lam.

10. Serpula contortuplicata, Linn., Long Beach.

11. Serpula vermicularis, Linn., common on shore of Sound. Gould, p. 10.

12. Serpula ——— ? Stonington, on bottom of ship from the Baltic.

Cirripeda.

Cirripeda sessilia.

13. Coronula balænaris, Lam., whale—Stonington. Gould, p. 13.

14. Balanus eburneus, Gould, Bridgeport bridge. Gould, fig. 6.

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*3. This species I found on *Modiola modiolus*, (Turton,) in deep water, Long Beach.

*7. I discovered a specimen of this species on *Pecten concentricus*, (Say,) on Long Beach.

*8. Dr. Skilton of Troy informs me, this shell is found in Long Island Sound.

15. Balanus elongatus, Linn. sp., Gould, on vessel at Bridgeport. Gould, fig. 8.

16. Balanus geniculatus, Conrad, ship's bottom, Stonington. Gould, fig. 9.

17. Balanus ovularis, Lam., Stratford, on timbers and stones, common. Gould, fig. 7.

18. Balanus rugosus, Mont., on vessel at Bridgeport. Gould, fig. 16.

19. Balanus spinosus, Lam. and Wyatt, ships at Stonington. Wyatt's Conch., p. 20.

20. Balanus Tintinnabulum, Linn. sp., Lam., on vessels, Bridgeport. Gould, p. 13.

21. Balanus sulcatus ? Lam., ship's bottom, Stonington, from Pacific Ocean.

Cirripeda pedunculata.

22. Anatifa dentata, Brug., on bottom of vessels, Bridgeport. Gould, fig. 11.

23. Anatifa lævis, Brug., on vessels in port. Gould, p. 19.

24. Anatifa striata, Brug., Stonington. Gould, p. 20.

25. Anatifa vitrea, Lam., on bottom of vessels, Bridgeport.

26. Cineras vittata, Leach, on ships in Stonington. Gould, p. 22.

27. Otion Blainvillii, Leach, ships at Stonington. Wyatt's Conch., p. 22.

28. Otion Cuvieri, Lam., ships at Stonington. Gould, p. 23.

Conchifera.

Order I. Conchifera bimusculosa.

Section 1. Conchifera crassipeda.

Tubicolaria.

29. Teredo navalis, Linn., shore of Sound, Stratford, and on floating wood, Stonington. Gould, p. 26.

30. Teredo ——— ? new species, very curious, Stonington, ship's bottom from Pacific Ocean.

Pholadaria.

31. Pholas crispata, Linn., Stonington. Gould, p. 27.

32. Pholas cuneiformis, Say, stomach of codfish, Stonington. Jour. Acad. Nat. Sci., Vol. II, p. 320.

33. Pholas truncata, Say. Dr. Jay says Connecticut, vide p. 8, of his Catalogue.

Solenacea.

34. Solen ensis, Linn., on sand beaches. Gould, p. 29.

35. Solen viridis, Say, on sand beaches, rare. Jour. Acad. Nat. Sci., Vol. II, p. 316.

36. Solecurtus caribæus, Lam. sp., Conrad, Long Beach, Stratford. Gould, p. 30.

37. Solecurtus (Machæra of Gould) costatus, Say, Stonington. Jour. Acad. Nat. Sci., Vol. II, p. 315.

38. Solecurtus fragilis, Conrad, rare, codfish stomach, Stonington. Gould, p. 31.

Myaria.

39. Mya arenaria, (mercenaria, Say,) Linn., long clam. O. L.

40. Mya subtruncata, Nobis, Oyster River; a steady and constant variety of *mercenaria.*

41. Anatina papyracea, Say, codfish, Stonington. Gould, fig. 28.

42. Thracia truncata, Mighels, codfish, Stonington, very rare.

43. Osteodesma hyalina, Conrad, sp., Couth., Long Beach, Stratford, and Stonington. Gould, fig. 31.

44. Cochlodesma Leana, Conrad, sp., Couthouy, Stratford and Stonington. Gould, figs. 29 and 30.

Section 2. Conchifera tenuipeda.

Mactracea.

45. Cumingia tellinoides, Conrad, Stonington. Gould, fig. 36.

46. Mactra similis, Say, Stratford. Jour. Acad. Nat. Sci., Vol. II, p. 309.

47. Mactra solidissima, Chem., (*M. gigantea*, Lam.) Stratford. Gould, p. 51.

48. Mactra lateralis, Say, Oyster River. Gould, figs. 34 and 35.

*49. Mactra quadrangulata, Nobis, Stratford and Stonington.

*50. Solemya borealis, Totten, Stonington. Gould, p. 36.

51. Solemya velum, Say, Stratford, Long Beach. Gould, p. 35.

52. Mesodesma arctata, Gould, (*Mactra arctata*, Conrad,) young, from codfish stomach. Gould, fig. 30.

53. Montacuta bidendata, Mont. sp., Gould, codfish, Stonington. Gould, p. 59.

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*49. This shell is found on our shore from Connecticut to Georgia.

*50. My specimen is $1\frac{4}{5}$ inch long.

54. Amphidesma æquale, Say, codfish, Stonington. Say's Conch., 3.

55. Kellia rubra, Turton, Stonington. Gould, fig. 33.

CORBULEA.

56. Corbula contracta, Say, Oyster River. Gould, fig. 37.

57. Pandora trilineata, Say, stream five miles east of New Haven light-house. Say's Am. Conch., plate 2.

LITHOPHAGA.

58. Saxicava distorta, Say, Oyster River. Gould, fig. 40.

59. Petricola dactylus, Stratford. Gould, fig. 41.

60. Petricola pholadiformis, Lam., Stratford. Gould, p. 63.

NYMPHACEA.

NYMPHACEA SOLENARIA.

61. Sanguinolaria fusca, Conrad, mouth of Housatonic. Gould, fig. 42.

62. Sanguinolaria sordida, Couthouy, sp., Gould, Stonington and Stratford. Gould, p. 67.

NYMPHACEA TELLINARIA.

63. Tellina Balthica, Linn., Stratford, young of *Sanguinolaria fusca.*

*64. Tellina solidula, Soland., Stonington.

65. Tellina tenera, Say, Stratford. Gould, fig. 44.

66. Tellina tenta, Say, Stonington. Gould, fig. 43.

67. Tellina versicolor, Cozzens, Long Beach, Stratford.

68. Lucina flexuosa, Mont. sp., Gould, codfish, Stonington. Gould, fig. 52.

69. Lucina radula, Mont. sp., Gould, Stonington. Gould, p. 69.

70. Astarte castanea, Say, Stonington. Gould, fig. 45.

*71. ASTARTE MACTRACEA, Nobis, codfish stomach, Stonington.

72. Astarte quadrans, Gould, Stonington. Gould, fig. 48.

73. Astarte sulcata, Mont. sp., Fleming, Stonington. Gould, fig. 46.

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*64. This species, which I sent to Dr. Gould, he thinks may be the *Tellina solidula* of Europe.

*71. The accompanying figure gives the form and size of this shell.

Section 3. Conchifera lamellipeda.

Conchæ.

Conchæ Fluviatiles.

74. Cyclas dubia, Say, Housatonic. Gould, fig. 56.
75. Cyclas elegans, Adams, Housatonic. Gould, fig. 55.
76. Cyclas minor, Mighels, Stonington. B. J. N. H., Vol. IV, pl. 4, fig. 2.
77. Cyclas nitida, Mighels, Stratford. B. J. N. H., Vol. IV, pl. 4, fig. 3.
78. Cyclas orbicularia, Barratt, East Haddam.
79. Cyclas partumeia, Say, Old Mill Hill brook, Stratford. Gould, fig. 54.
80. Cyclas rhomboidea, Say, Housatonic. Jour. Acad. Nat. Sci., Vol. II, p. 380.
81. Cyclas similis, Say, Weston. Gould, fig. 53.
82. Cyclas truncata, Nobis, Stonington, Stratford, and Stratfield.

Conchæ Marinæ.

83. Cyprina Islandica, Lam., codfish, Stonington. Gould, p. 83.
84. Cytherea convexa, Say, Stratford light-house. Gould, fig. 49.
85. Cytherea morrhuana, Nobis, codfish stomach, Stonington, new species.
86. Venus gemma, Totten, shore of Sound. Gould, fig. 51.
87. Venus mercenaria, Say, round clam. Gould, fig. 67.
88. Venus notata, Say, Stonington. Gould, fig. 67.

Cardiacea.

89. Cardium Grœnlandicum, Chemn., haddock stomach. Gould, p. 92.
90. Cardium Mortoni, Conrad, Stratford. Gould, p. 91.
91. Cardium pinnulatum, Conrad, codfish, Stonington. Gould, fig. 57.
92. Cardita borealis, Conrad, Stonington. Gould, fig. 59.

Arcacea.

93. Arca pexata, Say, Stratford. Gould, fig. 60.
94. Arca transversa, Say, Stratford and Fair Haven. Gould, p. 96.
95. Nucula limatula, Say, New Haven, and codfish, Stonington. Gould, fig. 62.

96. Nucula proxima, Say, codfish, Stonington. Gould, fig. 63.
97. Nucula sapotilla, Gould, codfish, Stonington. Gould, fig. 61.
98. Nucula tenuis, Turton, Stonington. Gould, fig. 64.

Naiada.

Margarita.

99. Unio cariosus, Say, Housatonic. Gould, fig. 72.

100. Unio complanatus, Solander, sp., Lea, and a variety finely rayed, Housatonic. Gould, figs. 68, 69, and 70.

101. Unio compressus, Lea, New Haven Canal.

102. Unio heterodon, Lea, Housatonic.

103. Unio nasutus, Say, Hartford and Stonington. Gould, fig. 71.

104. Unio ochraceus, Say, Housatonic. Gould, fig. 74.

*105. Unio Pequottinus, Nobis, Bridgeport.

106. Unio radiatus, Barnes, Connecticut River, Middletown. Gould, fig. 78.

107. Alasmodonta arcuata, Barnes, Trumbull River. Gould, fig. 75.

108. Alasmodonta marginata, Say, Housatonic, Derby, &c. Gould, fig. 77.

109. Alasmodonta undulata, Say, Housatonic. Gould, fig. 76.

110. Anodonta areolata, Swainson, Connecticut River, Hartford.

111. Anodonta fluviatilis, Dillwyn, sp., Lea, Wheeler's mill-pond, Stratford. Gould, fig. 80.

112. Anodonta Housatonica, Nobis, Housatonic at Corum.

113. Anodonta implicata, Say, (perhaps same as No. 114,) Connecticut River, Hartford. Gould, fig. 78.

114. Anodonta marginata, Say, Housatonic.

115. Anodonta undulata, Say, Housatonic. Gould, fig. 79.

116. Anodonta subcylindracea, Lea, Whitneyville.

Order II. Conchifera unimusculosa.

Mytilacea.

117. Modiola discors, Lam., Oyster River near New Haven. Gould, fig. 84.

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*105. I have in my cabinet one valve of this shell, which was found buried with Indian relics and an Indian corpse in Bridgeport, 1840, and which I think is evidently a new and undescribed species.

118. Modiola glandula, Totten, codfish, Stonington. Gould, fig. 87.

119. Modiola modiolus, Turton, Long Beach, Stratford. Gould, p. 123.

120. Modiola nexa, Gould, codfish, Stonington. Gould, fig. 86.

121. Modiola plicatula, Lam., Stratford, salt marshes. Gould, fig. 81.

122. Mytilus edulis, Linn., O. L. Gould, fig. 82.

123. Mytilus striatus, Dekay, (*pellucidus*, Pennant,) Stratford. Gould, p. 122.

Pectinida.

*124. Pecten concentricus, Say, Stratford. Gould, fig. 88.

125. Pecten Islandicus, Chemn., Stonington, in eel-pot. Gould, fig. 89.

126. Pecten fuscus, Nobis, codfish, Stonington.

Ostracea.

127. Ostrea borealis, Lam., long and narrow oyster. Gould, p. 137.

128. Ostrea costata, Dekay, ribbed oyster, Stratford.

129. Ostrea Virginica, Gmel., common round oyster. Gould, p. 136.

130. Anomia aculeata, Gmel., Stratford. Gould, fig. 90.

131. Anomia electrica, Linn., Stonington. Gould, p. 140.

132. Anomia ephippium, Linn., O. L. Gould, p. 138.

133. Anomia squamula, Linn., Stonington. Gould, p. 140.

Mollusca.

Order II. Gasteropoda.

Section 1. Hydrobranchiæ.

Phyllidiana.

*134. Chiton fulminatus, Couth., codfish, Stonington. Gould, fig. 23.

135. Chiton ruber, Lowe, Stonington, on *Buccinum undatum.* Gould, fig. 24.

136. Patella —— ? —— ? ships at Stonington from Pacific Ocean.

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*124. One hundred thousand bushels of the *P. concentricus* (scollop-shell) were taken in Stratford in the year 1841.

*134. Dr. Gould remarks that Dr. Loven says, this is "a very common species with us, (in Sweden.) I think it is the *Chiton lævigatus,* Fleming."

137. Lottia alveus, Conrad, sp., Gould, Stratford. Gould, fig. 13.

138. Lottia testudinalis, Muller, sp., Gould, Stratford. Gould, fig. 12.

CALYPTRACEANA.

139. Crepidula alata, Lea, Stratford, on oysters.

140. Crepidula convexa, Say, Stratford. Gould, fig. 15.

141. Crepidula depressa, Say, Stratford, on horse-foot, (*Limulus polyphemus.*) Jour. Acad. Nat. Sci., Vol. II, p. 222.

142. Crepidula fornicata, Lam., Stratford. Gould, fig. 17.

143. Crepidula glauca, Say, Stratford, on *Pecten concentricus.* Gould, fig. 14.

144. Crepidula plana, Say, Stratford, in old Pyrulas. Gould, fig. 16.

145. Ancylus fuscus, Adams, Norwich and Stratford. Gould, fig. 152.

146. Ancylus rivularis, Say, West River, New Haven. Gould, fig. 153.

147. Ancylus tardus, Say, Hockanum River, East Hartford.

BULLÆANA.

148. Bulla debilis, Gould, codfish, Stonington. Gould, fig. 95.

149. Bulla insculpta, Totten, mouth of Housatonic. Gould, fig. 96.

150. Bulla obstricta, Gould, Stonington. Gould, fig. 96.

151. Bulla oryza, Totten, Stratford. Gould, fig. 93.

152. Bulla triticea, Couth., haddock stomach, Stonington. Gould, fig. 98.

Section 2. PNEUMOBRANCHIÆ.

LIMACINA.

153. Limax campestris, Binn., Northford. B. J. N. H., Vol. IV, p. 169.

154. Limax marmorata, Dekay, Stratford. Dekay's Report, p. 31.

*155. Limax tunicata, Gould, Northford. Gould, p. 3.

Order III. TRACHELIPODA.

Section 1. TRACHELIPODA PHYTIPHAGA.

COLIMACEA.

156. Helix albilabris, Say, Stratford. Gould, fig. 101.

157. Helix alternata, Say, Stratford. Gould, fig. 114.

*155. This species is ascertained to be the same as *Limax agrestis,* Linn. Vide Bost. Jour. Nat. Hist., Vol. IV, p. 166.

158. Helix arborea, Say, Northford and Huntington. Gould, fig. 110.

159. Helix chersina, Say, Stonington and Hartford. Gould, fig. 105.

160. Helix cellaria, Müller, Huntington. Gould, fig. 104.

161. Helix electrina, Gould, Huntington and Stonington. Gould, fig. 111.

162. Helix fraterna, Say, Stratford. B. J. N. H., Vol. III, pl. 10, fig. 2.

163. Helix fuliginosa, Griffiths, Stratford.

164. Helix gularis, Say, Weston. Jour. Acad. Nat. Sci., Vol. II, p. 156.

165. Helix hirsuta, Say. Stonington and Weston. Gould, fig. 116.

166. Helix indentata, Say, Plymouth, Conn. Gould, fig. 109.

167. Helix lineata, Say, Stratford and Orange. Gould, fig. 103.

168. Helix labyrinthica, Say, Stonington and Hartford. Gould, fig. 106.

169. Helix minuscula, Binney, Hartford. Whittemore.

*170. Helix Trumbulli, Nobis, Stonington, at low-water mark.

171. Helix monodon, Rackett, Orange. Gould, fig. 113.

172. Helix pulchella, Müller, Stratford. Gould, fig. 102.

*173. Helix Sayii, Binney. B. J. N. H., Vol. III, pl. 16.

174. Helix suppressa, Say, Housatonic shore and Weston.

175. Helix striatella, Anthony, Stratford, Huntington, and Stonington. Gould, fig. 112.

176. Helix subglobosa ? Binney, Weston. Gould, p. 172.

177. Helix tridentata, Say, Stratford. Gould, fig. 115.

178. Pupa contracta, Say, shore of Housatonic. Gould, fig. 117.

*179. Pupa cortricaria, Say, Orange. B. J. N. H., Vol. III, p. 379, pl. 3, fig. 2.

180. Pupa pentodon, Say, Northford and Huntington. Gould, fig. 120.

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*170. *H. Trumbulli*, Nobis—spire much depressed or very little elevated; sutures slightly marked, and umbilicus large and deep; color a dull white with a tinge of green; shell thin and translucent; diameter about $\frac{11}{100}$ of an inch, height $\frac{1}{25}$ inch; found on the shore of Long Island Sound near high-water mark, and occasionally near low-water mark at Stonington, by Mr. J. H. Trumbull. [May not this shell be *Margarita arctica?*—Eds.]

*173. Binney says the *H. Sayii* "inhabits all the northern parts of the United States, from Illinois to Maine."

*179. This shell I found in the bark of a butternut tree by the roadside in Orange.

181. Pupa exigua, Say, Stratford. Gould, fig. 122.

182. Pupa fallax, Say, (*Cyclostoma marginata*, Say,) Housatonic shore. Gould, fig. 123.

*183. Pupa Gouldii, Binney, Northford. Proceedings B. S. N. H., p. 105.

184. Pupa Milium, Gould, Fisher's Island, Stonington. Gould, fig. 118.

*185. Pupa modesta, Say, Stonington. Gould, fig. 119.

186. Pupa ovata, Say, Stonington. Jour. Acad. Nat. Sci., Vol. II, p. 376.

187. Pupa simplex, Gould, Fisher's Island, Stonington. Gould, fig. 121.

188. Bulinus lubricus, Brug., Hartford. Gould, fig. 124.

189. Succinea avara, Say, Crimber's Neck shore. Gould, fig. 127.

*190. Succinea campestris, Say, Oldfield, Stratford. Gould, fig. 126.

191. Succinea ovalis, Say, Crimber's Neck shore. Gould, fig. 125.

192. Auricula bidentata, Say, sp., Gould, Stratford. Gould, fig. 130.

193. Auricula denticulata, Mont. sp., Gould, Stonington. Gould, fig. 129.

194. Cyclostoma lapidaria, Say, Housatonic. Jour. Acad. Nat. Sci., Vol. II, p. 14.

LYMNÆANA.

195. Planorbis armigerus, Say, Peck's lane, Stratford. Gould, fig. 138.

196. Planorbis bicarinatus, Say, Weston. Gould, fig. 134.

197. Planorbis campanulatus, Say, shore of Housatonic. Gould, fig. 133.

198. Planorbis deflectus, Say, Bantam Lake, Litchfield. Gould, fig. 136.

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*183. Dr. Binney observes that this species seems to be very common in the Middle States and in New England, though not before described.

*185. Prof. Adams distinguishes *Pupa modesta* from *P. ovata.* Dr. Gould has ascertained that the former was described from an imperfect specimen of the latter. B. J. N. H., Vol. IV, p. 351.

*190. I took of the *Succinea campestris* in Oldfield, Stratford, four hundred and fifty specimens in one afternoon.

199. Planorbis dilatatus, Gould, Yantic River, Norwich, and Wheeler's Pond, Stratford. Gould, fig. 140.

200. Planorbis elevatus, Adams, attached to Unio, Hockanum River. Gould, p. 207.

201. Planorbis exacutus, Say, Tashua church brook. Gould, fig. 135.

202. Planorbis hirsutus, Gould, Stonington. Gould, fig. 135.

203. Planorbis lentus, Say, Stratford pond on Harvey's farm. Gould, fig. 132.

204. Planorbis obliquus, Dekay, Stonington, and Thatchersville pond, Bridgeport.

205. Planorbis parvus, Say, shore of Housatonic. Gould, fig. 139.

206. Planorbis trivolvis, Say, shore of Housatonic, among drift. Gould, fig. 131.

207. Physa aurea, Lea, Stonington, variety of *heterostropha.*

*208. Physa elongata, Say, Housatonic. Gould, fig. 143.

209. Physa heterostropha, Say, Housatonic. Gould, fig. 141.

210. Physa Sayi, Tappan, Housatonic, variety of *ancillaria.* Hald., pl. 3, figs. 9, 10.

211. Lymnæa caperata, Say, (*umbilicata,* Adams,) Housatonic. Hald., pl. 11, figs. 1–12.

212. Lymnæa chalybea, Gould, Peck's lane brook, and Bridgeport. Gould, fig. 145.

213. Lymnæa columella, Say, Wheeler's mill-pond, Stratford. Gould, fig. 144.

214. Lymnæa decollata, Mighels, Housatonic. Hald., pl. 14, fig. 5.

215. Lymnæa desidiosa, Say, Orange and Milford. Gould, fig. 140.

216. Lymnæa elodes, Say, Housatonic. Gould, figs. 146, 147.

217. Lymnæa emarginata, Say, island in Housatonic.

*218. Lymnæa Linsleyi, Dekay, shore of Housatonic, and in Huntington near turnpike gate to Bridgeport.

219. Lymnæa macrostoma, Say, Peck's lane and Stratfield. Gould, fig. 148.

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*208. This is the *P. hypnorum,* Linn., vide Haldeman, pl. 5, figs. 4–9.

*218. "*Lymnæa Linsleyi,*" Dekay. "Characteristics—chesnut epidermis with blackish pigment. Body whorl flattened with waved incremental lines. Aperture twice the length of the spire." Animal, black. Picked up at Crimber's neck on shore of Housatonic, in March, 1841. Two specimens only—both of which I sent to Dr. Dekay.

220. Lymnæa modicellus, Say, (*humilis*, Hald., vide Hald., pl. 3, figs. 1–8,) Old Mill Hill brook, Stratford. Gould, fig. 151.

PERISTOMIANA.

221. Valvata pupoidea, Gould, Housatonic and Mystic Rivers. Gould, fig. 155.

222. Valvata tricarinata, Say, Housatonic. Gould, fig. 156.

223. Valvata unicarinata, Dekay, Bantam Lake, Litchfield.

224. Paludina decisa, Say, Housatonic, Corum. Gould, p. 227.

225. Paludina integra, Say, (*microstoma*, Kirtland,) Corum. Jour. Acad. Nat. Sci., Vol. II, p. 174.

226. Paludina lustrica? Say, (*Amnicola*, Gould,) Housatonic.

227. Amnicola Cincinnatensis, Anthony, Housatonic. Gould, p. 230.

228. Amnicola grana, Say, sp., New Haven. Jour. Acad. Nat. Sci., Vol. II, p. 174.

229. Amnicola porata, Say, sp., Gould, Housatonic. Gould, fig. 157.

230. Amnicola pallida, Haldeman, Hartford; nearly white.

NERITACEA.

231. Natica duplicata, Say, Stratford light-house. Gould, fig. 164.

232. Natica flava, Gould, haddock, Stonington. Gould, fig. 162.

233. Natica Heros, Say, Long Beach, Stratford. Gould, fig. 163.

234. Natica immaculata, Totten, cod stomach, Stonington. Gould, fig. 168.

235. Natica triseriata, Say, Stratford and Stonington. Gould, fig. 165.

PLICACEA.

236. Tornatella puncto-striata, Adams, Stonington, haddock. Gould, fig. 188.

SCALARIANA.

237. Vermetus lumbricalis, Lam., New Haven and New Bedford. Gould, p. 246.

238. Scalaria Clathrus, Say, Stonington. Say's Am. Conch., pl. 27, fig. 3.

239. Margarita obscura, Couthouy, sp., Gould, haddock stomach, Stonington. Gould, fig. 3.

240. Turbo multilineatus, Dekay, Stratford. Dekay's Report, p. 32.

241. Lacuna neritoidea, Gould, Oyster River and Long Beach. Gould, fig. 170.

242. Lacuna vincta, Mont. sp., Gould, (*fusca*, Dekay,) Oyster River and Long Beach. Gould, fig. 178.

243. Lacuna ——— ? stomach of spirit duck.

244. Cingula aculeus, Gould, Stratford. Gould, fig. 172.

245. Cingula arenaria, Montagu, sp., codfish, Stonington; *rare.*

246. Cingula minuta, Totten, sp., Gould, Stratford and Stonington. Gould, fig. 171.

247. Littorina irrorata, Say, on high sedge, Stratford. Jour. Acad. Nat. Sci., Vol. II, p. 239.

248. Littorina neritoides, Dekay, Stratford.

249. Littorina palliata, Say, sp., Gould, Stratford. Gould, fig. 177.

250. Littorina rudis, Mont. sp., Gould, Stratford. Gould, fig. 175.

251. Littorina tenebrosa, Mont. sp., Gould, Stratford. Gould, fig. 176.

252. Pyramis striatula, Couth., stomach of spirit duck, Bridgeport. Gould, fig. 174.

253. Turritella erosa? Couth., codfish, Stonington. Gould, p. 267.

254. Turritella interrupta, Totten, codfish, Stonington. Gould, fig. 173.

255. Odostomia exigua, Couthouy, sp., Gould, on *Pectens*, Crimber's neck, Stratford. Gould, fig. 177.

256. Odostomia fusca, Adams, sp., Gould, on *Pectens*, Stonington. Gould, fig. 176.

257. Odostomia limnoidea, Dekay, stomach of *Anas acuta;* six hundred specimens.

258. Odostomia producta, Adams, sp., Gould, Stonington and Stratford. Gould, fig. 175.

259. Odostomia seminuda, Adams, sp., Gould, five on a cluster of *Crepidula fornicata*, Stratford. Gould, fig. 178.

260. Odostomia trifida, Gould, (*Actæon*, Tott.) on *Pectens*, Long Beach. Gould, fig. 174.

Section 2. Trachelipoda Zoophaga.

Canalifera.

261. Cerithium nigrocinctum, Adams, Stonington, on oysters from Chesapeake Bay. Gould, fig. 182.

262. Cerithium Sayi, Menke, Stratford. Gould, fig. 183.

263. Pleurotoma bicarinata, Couthouy, Stonington. Gould, fig. 186.

264. Fasciolaria ligata, Mighels and Adams, codfish, Stonington. B. J. N. H., Vol. IV, pl. 4.

265. Fusus borealis, Dekay, Long Beach, Stratford.

266. Fusus corneus, Say, (young,) codfish, Stonington. Say's Am. Conch., pl. 29.

267. Fusus imbricatus, Dekay, Long Beach, Stratford.

268. Fusus harpularius? Couth., Stratford. Gould, fig. 191.

*269. Fusus Trumbulli, Nobis, stomach of haddock, Stonington.

270. Pyrula canaliculata, Brug., common winkle. Gould, fig. 126.

271. Pyrula carica, Brug., more rare. Gould, p. 296.

272. Ranella caudata, Say, Long Beach, Stratford. Gould, fig. 204.

Purpurifera.

273. Purpura lapillus, Say, many varieties, Stonington. Gould, p. 301.

274. Buccinum lunatum, Say, Stratford. Gould, fig. 196.

275. Buccinum obsoletum, Say, Stratford. Gould, fig. 210.

276. Buccinum plicosum, Menke, Stratford. Gould, fig. 213.

277. Buccinum rosaceum, Gould, Stonington. Gould, fig. 195.

278. Buccinum trivittatum, Say, Stratford. Gould, fig. 211.

279. Buccinum undatum, Linn., Stonington, taken in eel-pots. Gould, p. 305.

280. Buccinum vibex, Say, New Haven. Gould, fig. 212.

281. Buccinum zonalis, Nobis, stomach of haddock, Stonington.

Columellaria.

282. Columbella avara, Say, Stratford. Gould, fig. 197.

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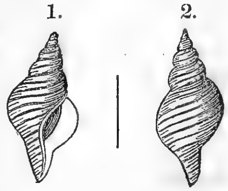
*269. This is without doubt a new species, (allied to *F. decemcostatus*, Say,)—has a thin, woolly, brownish white epidermis. Length $\frac{9}{20}$ of an inch, width $\frac{7}{40}$, whorls 6. The accompanying figure will serve to show its form. It is enlarged from the length of the accompanying line.



Magnified.

Order IV. Cephalopoda.

Division 1. Polythalamous Cephalopoda.

Nautilacea.

*283. Nautilus Connecticutensis, Nobis, (sinistral,) Stonington.

Division 3. Naked Cephalopoda.

284. Loligo illecebrosa, Le Sueur, (ink fish,) Long Island Sound. Gould, p. 318.

285. Loligo punctata, Dekay, Long Beach. Dekay's Report, p. 31.

Radiata.

Echinodermata.

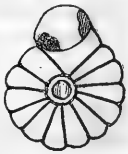
286. Echinus granulatus, Say, Stratford. Gould, p. 344.

287. Scutella parma, Rumphius, codfish, Stonington. Gould, p. 344.

*288. Holothuria briareus, Le Sueur, Stratford Point. Gould, p. 346.

Mr. Linsley detected many animals in Connecticut belonging to the classes *Crustacea* and *Annelida*, of which, to our regret, he has left no catalogue, but merely pencilings among his records. Some few species of *Helices*, found by Dr. Skilton in Troy, N. Y., he also considered inhabitants of our state; but as there appeared to be uncertain data, they are omitted in the preceding list. E. L. L.

Elmwood Place, Stratford, October 5, 1844.



*283. This beautiful little shell I have in my cabinet. It seems to be the first specimen of its genus or its family found on our shores. Dr. Gould in his Report, p. 317, remarks, "of the very curious and minute *Nautilacea*, so many of which have been found about the British islands, there are doubtless many among the sands of our shores; but none have as yet been detected." My specimen is about $\frac{1}{70}$ of an inch in length; found at Stonington on the roots of kelp.

*288. I sent a specimen of this species, found in Stratford, to Dr. Storer, who forwarded it to Philadelphia, a description of which subsequently appeared in the Journal of the Academy of Natural Sciences.

ART. VII.—*Abstract of a Meteorological Journal, for the year* 1844, *kept at Marietta, Ohio,* Lat. 39° 25′ N., Lon. 4° 28′ W. of Washington City; by S. P. HILDRETH, M. D.

MONTHS.	THERMOMETER. Mean temperature.	Maximum.	Minimum.	Fair days.	Cloudy days.	Rain and melted snow, in inches.	Prevailing winds.	BAROMETER. Maximum.	Minimum.	Range.
January, - -	29·97	60	0	12	19	2·42	N. W., N.	29·80	29·10	·70
February, -	37·66	64	6	16	13	1·08	N., S. W.	29·70	29·10	·60
March, - -	42·77	73	10	12	19	2·83	S. W., S. E.	29·85	29·09	·74
April, - -	61·20	90	24	19	11	0·70	S., S. W.	29·85	29 35	·50
May, - -	63·76	87	36	19	12	5.75	S. W., S.	29·67	29·18	·49
June, - -	68·21	89	48	20	10	4·12	S. W., S. E.	29·75	29·35	·40
July, - -	75·21	90	57	20	11	7·75	S., S. E.	29·60	29·30	·30
August, - -	69·51	90	52	21	10	2·17	S. W., W.	29·55	29·28	·27
September, -	64·62	87	37	22	8	2·87	S., S. E.	29·70	29·20	·50
October, - -	48·86	73	24	16	15	3·54	S. W., N. W.	29 80	29·20	·60
November, -	42·93	70	17	16	14	2·54	S., S. W., W.	29·75	29·18	·57
December, -	34·37	63	13	16	15	0·87	S. W., N. W.	29·75	29·05	·70
Mean,	53·25			209	157	36·64				

Remarks on the year 1844.—In the year which has now passed, there has been nothing very remarkable to distinguish it from common years, except the early progress of vegetation in the spring months, and the great amount of rain in the fore part of summer, while the quantity for the year is less than usual. The changes of temperature in different years do not so materially affect the productions of the earth, as the excess or the lack of moisture. By the withholding of the rains at certain seasons, when plants are vegetating, or the cereal crops are ripening their seeds, the amount of product is materially affected; while the earlier or later appearance of summer heat may only accelerate or retard the ripening of grains or fruit, without greatly altering the quantity. The seasons in this beautiful valley of the Ohio are never in such extremes as to blast the expectations of the husbandman. If his crops of wheat or rye are injured or cut off by the blight, his Indian corn, oats and potatoes make up for the failure, and secure the land from the dire effects of famine, that terrible scourge of some portions of Asia and Africa. At no period since this valley has been fairly settled, have the inhabitants suffered from a want of bread-stuffs, and so abundant have been the crops, that those who purchased had them at a cheap rate.

The only complete failure of any staple crop was that of potatoes in the year 1838, from the effects of a drought, confined chiefly to Ohio. From facts observed in the older quarters of the earth, it is probable that we shall continue to have a sufficient supply of rain for the growth of our crops, so long as the larger portion of the country remains clothed with forest trees. That forests have quite a large influence on the clouds, in attracting moisture and rain, and in preserving the earth from degeneration, has been long observed; and those regions of the earth which are destitute of trees, are known to suffer greatly from drought. Our hills are not sufficiently elevated to have much influence on the clouds, or they might in part supply the place of trees in attracting moisture from the skies. But the bowels of the earth in this favored valley are so fully replenished with bituminous coal, that many ages must elapse before our forests will all be needed for fuel. While they remain in one third of their present amount, it is not likely that the region of the Ohio will feel permanently and injuriously the need of a sufficient supply of rain.

The mean temperature for the past year was 53°·25, which is nearly three degrees more than that of the year preceding.

The amount of rain was 36·64 inches, being 5·12 inches less than that of 1843; nearly the half of which fell in the three early summer months; as the summer may be said to have commenced early in May this year, instead of June.

Seasons of the year.—The mean temperature of the winter was 34°·21, which is about two degrees warmer than that of the preceding year. The Ohio River was at no period frozen over, although at times there was so large a quantity of floating ice, as to stop for a few days the running of steamboats. The last week in January the cold was pretty severe, falling on the morning of the 27th to zero; but at no other time during the winter did the mercury sink to any point near this. There fell a considerable amount of snow during the winter; the largest at any one time was eleven inches, but it was soon melted away by the sun and rains. So moderate was the cold, that ice of sufficient thickness was not formed to put up in our ice-houses; and only a small quantity was saved late in February, taken up in the Ohio River, as it floated down from the breaking up of the Allegheny. The want of this valuable article was keenly felt by the sick, and in the domestic economy of the inhabitants of Marietta, during the ensuing long and hot summer months.

The mean temperature for the spring months was 55°·91, which is almost ten degrees greater than the spring of 1843, and approaching nearly to the temperature of 1842. The most marked difference was seen in the months of March and April. In the former month the excess was 14°·52, and in the latter nearly ten degrees. In May the variation was three degrees. The early progress of spring produced a corresponding growth in trees and plants, but not at so rapid a rate as in March, 1842, which was ten degrees warmer than the same month in 1844, and twenty four degrees than March in 1843. The mean of the spring of the two former years varied only 1°·20 ; that of 1842 being 57°·11, which is the highest of any one on record for the last twenty years, or probably since Marietta was settled. From my floral calendar it will be seen, that the progress of vegetation in March was not so rapid, but that the deficiency was made up in April, which shows a heat of nearly two and a half degrees greater than that of the corresponding month in 1842. The following list of the periods of blossoming of well known plants and trees, and the ripening of fruits, will be interesting to the botanist and to the lovers of horticulture in the valley of the Ohio, if not in the Atlantic states, when compared with those in the same parallel of latitude east of the Allegheny ranges.

March 1st, Robin, Turdus migratorius, appears; 5th, blackbird, Quiscalus versicolor; 6th, striped crocus in blossom; 10th, crown imperial six inches high; 13th, yellow crocus in full bloom; 18th, snowing—fell five inches; 20th, Hepatica triloba in bloom; 26th, purple martin, Hirundo purpurea, appears; 28th, early hyacinths in bloom.

April 2d, crown imperial in bloom; 3d, American cowslip, Dodecantheon Meadia; 4th, hyacinth and narcissus; 5th, peach trees in bloom—gooseberry; 6th, Sanguinaria Canadensis and Anemone Virginiana, cultivated in the garden—the latter often becomes quite double under the fostering care of man; 7th, Hydrastris Canadensis, yellow root—Mespilus arborea, June berry; 8th, imperial gage and red currant; 9th, sugar maple quite green with foliage; 10th, pear and cherry tree—Polyanthus narcissus—early strawberry, or Fragraria Hudsonii; 12th, Cornus florida opening its blossoms—Trillium thalictroides—Cineraria Canadensis; 13th, Cercis Ohioensis, red-bud—apple in full bloom—Anona triloba, papaw; 14th, Ranunculus acris—Corydalis cucullaria,

fumitory; 15th, Cornus florida in full bloom. In 1842, this splendid flowering tree was in blossom on the 5th of the month, and in 1843 it was as late as the 5th of May. 16th, Prunus Chickasa, wild plum—garden tulip begins to open its blossoms; 17th, lilac. The apple tree has commenced shedding its blossoms; grass, in pastures and meadows, is as far forward in its growth as it commonly is by the middle of May. 18th, Convallaria majalis, lily of the valley—Viola pubescens—Ranunculus bulbosa, an extra double variety, of great beauty; 19th, tulips in full bloom—a bed of more than two thousand plants, embracing a great variety of colors, makes a gorgeous display; Robinia pseudacacia putting forth its leaves; 21st, Morus rubra and quince tree. The white oak putting forth leaves, and the forest generally green with foliage. 23d, Pæonia montan, purple tree peony. Peas planted the 20th February in bloom. 27th, Cratægus coccinea; 28th, locust. This tree in the year 1842, which was remarkable for its early spring, did not blossom till the 6th of May; but the excessive heat of April has forced its dormant sap like a hot-house into a premature growth. In common years this tree blossoms the latter part of May. 30th, Harrison's double yellow and white Scotch rose.

May 1st, Liriodendron tulipifera; 2d, Prunus Virginiana and Rubus villosus; 5th, crimson peony; 8th, white peony; 11th, peas fit for the table, grown in open ground, without the aid of reflected heat; 12th, Juglans nigra—in common years this tree blossoms before the locust; 15th, Maclura aurantica; 19th, strawberry begins to be ripe; 22d, frost this morning, but not hard enough to do much damage.

June 2d, red mulberry ripe; 4th, common red cherry; 5th, native Rosa rubra in bloom; 7th, Catalpa and Sambucus Canadensis; 8th, Rubus occidentalis, native raspberry, ripe; 11th, red and white Antwerp raspberry ripe; 15th, golden drop apple ripe.

July 5th, Rubus villosus ripe; 6th, Althea in bloom; 7th, Vaccinium dumosum, whortleberry, ripe; 24th, Aralia spinosa in bloom. This showy shrub is well worth a place in the garden, for its late flowering. The huge umbelliferous spike of white flowers, crowning the top of the plant, has a very grand appearance. In its native haunts, along the rich side-hills of the valley of the Ohio, it is loaded with large clusters of blue berries, but in a state of cultivation it is always barren. The pollen is of so rich

and sweet a taste, that the bees, flies and wasps pull it all off, thus destroying its fructifying power before it has had time to impregnate the fruit germs.

The mean temperature of the summer months was 70°·97, which is three and a half degrees greater than that of 1842, and nearly equal to that of 1843, which was a hot summer. The last month of spring and first two of summer were uncommonly wet. There fell in these three months 17·62 inches of rain, lacking only 1·20 inches of being equal to that of the other nine months. The night between the 2d and 3d of July will long be remembered for the greatest fall of rain ever known in Marietta. It amounted to 4·25 inches. It was attended with but little thunder and quite moderate wind, blowing from the southwest, and changing to southeast. I was told by several people of veracity, that buckets which they had left out, and knew to be empty in the evening, were full of water in the morning. This would make six or eight inches; but my rain-gauge, which stands in an open place in my garden, contained only four and a quarter inches. The low grounds on the small streams were all overflowed, and much grass and grain destroyed. The Hockhocking bottoms were flooded, and large quantities of wheat, which had been reaped and stood in shocks, were swept off and floated down the current. From early in May to the last of July, the whole valley of the Mississippi, from the Rocky to the Allegheny Mountains, was deluged with rain. On the Missouri and Mississippi rivers the floods were unprecedented, and the destruction of crops, herds, fences and buildings, without a parallel since the settlement of the country. The excessive moisture and heat of June and July was very injurious to the wheat crops, causing a mildew and rust on the delicate cuticle of the straw, and thus blighting the grain. The produce of many fields was nearly destroyed. In the northern portion of Ohio, the growth is somewhat later, and the wheat less injured. The crops of Indian corn were never better, being superior both in quality and amount. By the 24th of August, along the Ohio River bottoms, corn planted in April was fully ripe, and the farmers commenced harvesting by cutting it up and setting it in shocks to dry. In common years, corn is ripe about the 20th of September. The production of potatoes, oats and grass, was uncommonly good. Sweet potatoes succeeded very finely, the heat and rains of the summer approaching to that of the tropics, their native habitat.

The mean temperature of the autumn months was 52°·13. Crops of fruit were not so large as in the preceding year, but there was a fair supply. The uncommon warmth of the spring and early summer hastened the ripening of fruits very considerably before the usual period. Winter apples, a staple crop with many of the farmers near the Ohio, were ripe nearly a month earlier than in common years. The Baldwin apple, a favorite winter fruit for the table in Massachusetts, was ripe the last of August, and, before the period of gathering this crop, had nearly all dropped from the tree. This I find to be the case with several of the valuable eastern apples. The heat of the western summers changes them from a winter to an autumn fruit. The close of the year has been very mild and temperate. The coldest morning in December was 13° above zero. There has been but little snow, and the ice in the Ohio River has not checked the navigation by steamboats. The last day of December, the mean temperature was 41°, and to-day, the first of January, 1845, it is 41°·33, with a calm, mild, and rather hazy condition of the atmosphere, similar to that of "Indian summer."

Marietta, January 1, 1845.

Art. VIII.—*Description of some Microscopic Shells from the Decomposing Marl Slate of Cincinnati;* by James Hall.

A few weeks since, Mr. J. Carly of Cincinnati placed in my hands a small tube phial containing at least five hundred individuals of different species of fossil shells, discovered by him in the soft decomposing marly slates around Cincinnati. Much credit is due to so faithful and accurate an observer as Mr. Carly, who devotes his leisure moments to the investigation of the fossiliferous beds of his neighborhood, enriching his own cabinet, and not unfrequently, as in the present instance, adding to the numbers of species already known, and to the extent of our knowledge, by his discoveries.

For the information of those unacquainted with the geological relation of the formations about Cincinnati, it may be proper to state, that the strata consist of alternations of shale and limestone, more or less pure. Much of the shale is very calcareous or marly, decomposing into a marly clay, charged with a profusion of organic remains. Sometimes indeed it presents all the appearance

of a beach bordering a coral reef, and abounding in shells and fragments of corals cemented together by calcareous and argillaceous mud. It is by washing this marly clay, and examining it by the aid of a magnifier, that Mr. Carly separates the fossils under consideration, and also, as he informs me, others of a still smaller size.

The age of these strata has been settled beyond a question, and they are universally regarded by geologists as synchronous with the lower Silurian of England and Wales, and as corresponding to the rocks of the Mohawk and Hudson valleys in New York. This identity is manifest from a comparison of numerous organic remains, and from stratigraphical succession. The principal difference, and that which gave rise to doubts of the correctness of the inference, is the great proportion of calcareous matter existing in the rocks of the West, while those of the Hudson valley are nearly destitute of that material. This fact however is perfectly reconcilable with all the other appearances, and we find the fossil testacea of these western rocks much more numerous and better developed than the same species in New York. So great indeed is the disparity in size and form of the same species, that several of them are not recognized as the same, and have been described under different names.

Among the fossils known to appear in the same association as the minute species before us, are the *Isotelus gigas*, *I. megistos*, *Calymene senaria*, *Trinucleus Caractaci*, *Triarthus Beckii*, *Ceraurus pleurexanthemus*; *Delthyris*, two or more species; *Atrypa*, *Strophomena alternata*, *S. sericea*, and other species; *Orthis testudinaria*, *O. callactis*, and other species; *Cypricardia modiolaris*, *C. angusta*, *Cyrtolites ornatus*, *Bellerophon bilobatus*, and numerous other forms.

Several of these forms are common both tô the limestones of the Mohawk valley and to the shales of the Hudson River group; but at the West, the great augmentation of calcareous matter has rendered it impossible to define with the same exactness the subdivisions of the groups as they appear in New York. Without dwelling upon this part of the subject at the present time, I will briefly notice the fossils in question, presuming that, from their great numbers, uniform size, and apparent perfection and maturity of growth, they are adult individuals. No species of larger size which can be identical with these, are known in the same

rocks, and therefore it is a natural inference that these are full grown.

The following are clearly identified as specifically distinct, and are all presumed to be new.

Genus MICROCERAS. Convolute, volutions few, horizontal, rapidly diminishing from the aperture; aperture subrhomboidal; shell subcarinated upon the back, chambered?

This fossil shell approaches to the genus Cyrtolites of Conrad; the whorls are contiguous but not involute, as in Bellerophon and Goniatites. It is not easy to determine whether this fossil be chambered or not.

MICROCERAS *inornatus.* Volutions about two, rapidly diminishing; spire equally depressed on either side, obtusely carinated or angular upon the back; carina more conspicuous near the mouth, and gradually becoming obsolete; aperture somewhat quadrangular; surface smooth.

Largest diameter $\frac{1}{20}$ of an inch.

Genus CYCLORA. Subglobose, shell thin, spire short, consisting of a few whorls; columella smooth, slightly reflected over a minute umbilicus, aperture circular.

N. B. The generic characters here given may be so extended as to include several shells of the palæozoic strata which cannot properly be included under existing genera.

CYCLORA *minuta.* Smooth; volutions about three, rapidly expanding towards the mouth; spire moderately elevated; aperture round and well defined. The last whorl forms the principal part of the shell.

Height of shell $\frac{1}{30}$ to $\frac{1}{20}$ of an inch.

This species is exceedingly numerous among those obtained by Mr. Carly, there being twice as many of this one as of all the others.

TURBO? *parvulus, n. s.* Spire elevated, volutions about four, smooth; first whorl angulated upon the centre towards the aperture; outer edge of the aperture projecting downwards.

Height of shell $\frac{1}{15}$ of an inch.

NUCULA *obliqua, n. s.* Subquadrangular; hinge-line short, oblique; beaks very prominent; edges of the shell thin; anterior side abruptly rounded, posterior slope abrupt.

Length and breadth about equal, $\frac{1}{20}$ of an inch.

This shell bears a close resemblance to a species of Nucula in the Trenton limestone.

NUCULA *fabula.* Shell twice as wide as long, smooth; beaks moderately prominent; crenulations along the hinge-line very obvious; muscular impressions on the anterior side of the beaks very distinct in the cast.

Width of largest specimen $\frac{1}{12}$ of an inch; generally less.

ORTHIS *costata, n. s.* Semicircular or semioval; surface marked by about twelve strong ribs; area well defined, proportionally large; hinge-line scarcely equal to the width of the shell, which is about $\frac{1}{15}$ of an inch.

This may perhaps be a young shell, but I have seen no large individual of the same species. The ribs are remarkably strong for a species of Orthis.

Besides the shells enumerated, there is a small Atrypa found associated with them; the same however is found in the Trenton limestone in New York, and will be described elsewhere. Some small Tentaculites and minute spiculæ of some kind also occur with these shells, but I have thus far been unable to refer them to any known fossil. Mr. Carly also informed me that other fossils, much more minute, occur in the marly clay, and it is not improbable that the microscope of Prof. Bailey may be called into requisition to decide the characters of these ancient microscopic beings.

From the geological position of these minute fossil shells, and from their great numbers, we may presume that they are widely distributed, but are discoverable only under favorable circumstances. The minute species of Atrypa, which occurs with them in considerable numbers, I have also found in the Trenton limestone; but it is scarcely probable that those here described, which are still much more minute, would be detected at all. They might even exist in considerable numbers in a compact limestone, associated with fragments of corals, crinoidal joints, and broken shells, without being detected by the naked eye.

The occurrence of those here described is sufficiently interesting to induce a careful examination in all our older strata for minute fossil shells; and since they are known in other formations and in a recent state, there seems no good reason why they may not be found from the commencement of organic existence.

Albany, December 10, 1844.

Art. IX.—*Review of the New York Geological Reports.*

(Continued from Vol. xlvii, p. 380.)

Grey Sandstone, Shawangunk Grit, and Oneida Conglomerate. (Formation IV, of Pennsylvania and Virginia.)—By referring to the table on page 355, Vol. xlvii, of this Journal, it will be observed that the Oneida conglomerate forms with the Medina sandstone and Clinton group, a transition series or connecting link between the lower and middle divisions of the New York system. The eastern geologists are not agreed as to the exact geological position of these strata. Hall, in his tabular arrangement, places the Oneida conglomerate as the highest member of the Champlain division. Vanuxem considers it a member of the Ontario division subordinate to the Clinton group, as will appear from the following extract from his Report, p. 75: "The Oneida conglomerate forms a part of the Clinton group, the next mass in the order of superposition. It was separated, as being a convenient point for division, and from the importance which was once attached to this rock, having been confounded with the conglomerate of the coal era, thus giving rise to the wildest calculations and distorting the whole of the geology of western New York." Mather considers the Shawangunk grit a member of the Ontario division, but lying probably below the Medina sandstone, for speaking of the strata composing the Ontario division, he says: "the rocks of this division may be classed under two groups, 1st. *Pyritous strata and red shales and grit* (above); 2d. *Shawangunk grit*, or *conglomerate*, (beneath); and 3d. A range of rocks similar to the above, but the identity of which is *not completely demonstrated.*" And again on page 355 of Mather's Report, we find the following paragraph regarding the above strata: "The observations made do not render it certain, whether these rocks are equivalent to the Onondaga salt group or the Medina sandstone, but it is thought probable from some of the mineral characters, no fossils having been seen, that they belong to the epoch of the Medina sandstone, and that the subjacent Shawangunk grit is equivalent to the grey sandstone instead of the Oneida conglomerate."*

* As we understand it, the identity of the Oneida conglomerate and Shawangunk grit is not doubted by the New York geologists.—Eds.

The probability is, that all these siliceous deposits, viz. the grey sandstone, Shawangunk grit, and Oneida conglomerate, should be grouped as one formation, as has been done in Pennsylvania. There the sandstones and conglomerates of the Kittatinny or Blue Mountain, (a continuation of the Shawangunk Mountain,) are all included in formation IV; they lie between formation III, the great slate stratum of the Kittatinny valley (Hudson River group of New York) and formation V, the red and variegated sandstones of the valley northwest of the Kittatinny Mountain, (Medina sandstone and Clinton group of New York.)

In New York these rocks are almost destitute of fossils. In Pennsylvania, Rogers found some *Fucoides*, and a "small and very globose species of *Terebratula* in it." The Esopus millstones of New York were quarried in the Shawangunk grit near the village of Kingston. "The fine-grained grits of this formation would make a beautiful and durable building stone."

Veins of lead ore traverse the Shawangunk grit. The Ulster lead mine near Redbridge on the Shawangunk Mountain, and the Ellenville lead mine at the base of the same mountain, have been worked by the North American Coal and Mining Company. So far these mines have not proved productive, and the ore is difficult to work in consequence of being much intermixed with blende.

The usual thickness of the Shawangunk grit is from sixty to one hundred feet; its maximum in New York is supposed to be about five hundred feet. This formation increases rapidly in thickness, going southward in Pennsylvania; at the water gap of the Lehigh, according to Rogers, it is increased to at least two thousand feet.

Medina Sandstone. (Lower part of formation V, of Pennsylvania.)—This formation is a red or variegated siliceous mass; for the most part a solid rock, but marly and friable in its western extension. Interstratified with it are grey bands of quartzose sandstone. Marine plants or *Fucoides*, are almost the only organic remains of the red portions; whereas the grey sandstone beds afford marine shells.

The superficial outcrop of these strata is represented on the chart by a light red belt bordering the southern shore of Lake Ontario; narrow in the east, especially in Wayne County, but expanding westward where it enters Canada.

Its greatest thickness is near Niagara River, where Hall estimates it at three hundred and fifty feet. In Canada it is probably still thicker. It gradually becomes thinner in an easterly direction, and thins out entirely in Oneida County. The scenery in the region of the Medina sandstone is often highly picturesque. The falls of Medina and Genesee are formed by its escarpments. The former of these localities on Oak Orchard Creek, is considered the most interesting for collecting its organic remains; here also it exhibits Hall's fourfold subdivisions, viz.

1. Red marl and shaly sandstone.
2. Grey quartzose sandstone.
3. Red shale and sandstone.
4. Greenish grey argillaceous or siliceous sandstone.

The second subdivision furnishes good flagstones, and is also the fossiliferous portion. Its fossil genera are: *Lingula*, *Cytherina*, *Pleurotomaria*, with a few *Bellerophon*, *Cypricardia* and *Orthoceras;* almost all however abraded and broken, indicating a troubled condition of the sea in which the deposite occurred.

Hall conjectures that the red deposites above and below this grey, fossiliferous band, were the products of a mud volcano highly charged with oxide of iron and rapidly spreading over the surface, rendering the sea turbid and overwhelming all organic forms.

Diagonal lines of lamination are often strongly marked in the sandy strata at Rochester. Black or dark colored sandy accretions, around which the strata have been deposited, are seen in the second subdivision at Lewiston, and oblong or rounded accretions of shale are observable also in the third subdivision.

At the extreme eastern extension of the Medina sandstone, it assumes the form of a conglomerate.

The soil derived from the formation under consideration is various; sometimes sandy, but more frequently a stiff loamy clay susceptible of improvement, and affording by cultivation a fertile soil.

Small quantities of copper and iron pyrites with oxide of manganese and iron, together with carbonate of copper, are the only metallic substances that have been discovered in this rock. At Rochester small spherical masses of reddish sulphate of barytes occur, filling cavities in the rock.

At Gasport on the Erie Canal, carburetted hydrogen issues from the Medina sandstone in sufficient quantity to light up a large room, but nowhere can it be collected in such abundance as to be of much practical benefit.

Brine springs occur throughout the whole extent of the formation; they issue at the outcropping edges of the siliceous portion of the mass, especially at the junction of the second division with the underlying impervious beds. This salt water is not sufficiently pure and strong to compete now with the brines of Salina, but formerly a considerable quantity of salt was manufactured from the springs in question. The existence of brine springs along the whole range of the Medina, together with the lithological similarity of its deposites to the red shale below the Onondaga salt group, caused it to be confounded for a time with this latter formation.

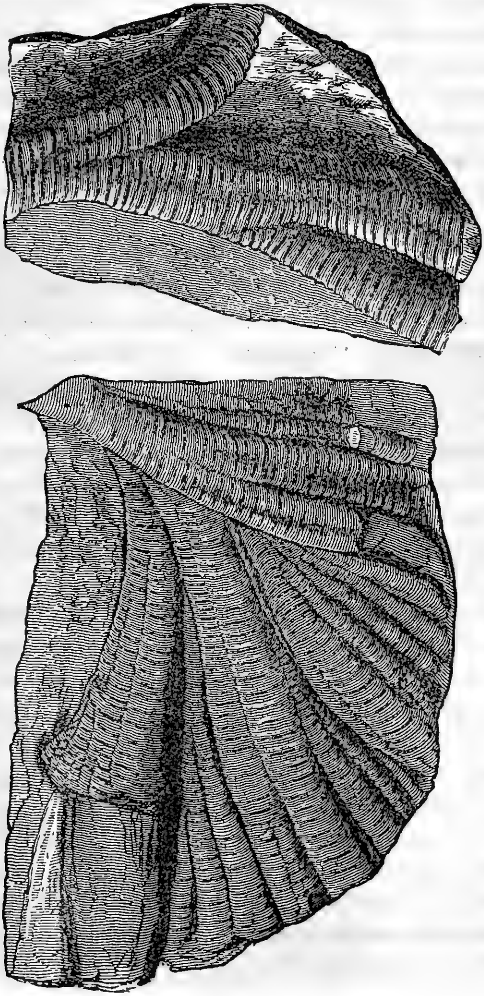


Plate 5, p. 46, Hall's Report.

1. 2.

Figs. 1 and 2. *Fucoides Harlani.*

The *Fucoides Harlani* is the typical and most widely distributed fossil of the Medina formation. Mr. Vanuxem found it in equivalent strata both in Pennsylvania and Virginia. There seems to be some discrepancy in the Report, as to the exact position it holds in the Medina formation. We find in Hall's Report the succeeding paragraphs: "In the *third* division of the rock two species of *Fucoides* abound in great perfection, the *F. Harlani* and the *F. auriformis.*" And elsewhere, speaking of the *F. Harlani:* "This is the most characteristic and widely diffused fossil of this rock. Its vertical range is very limited, holding a place near the *upper* part of the mass."* And again: "In the *upper* division, the only fossil known is the *Dictuolites Beckii* of Conrad. This is one of the most interesting fossils found in the rock, often covering large surfaces with its strong ridged branches and beautiful intercalated rootlets." Below are the shells figured in Hall's Report, found in the grey sandstone, (second division.)

Plate 6, p. 48, Hall's Report.

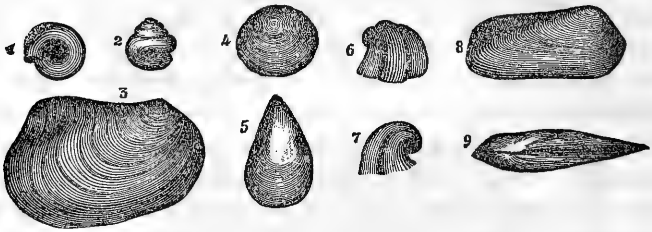


Plate 6, figs. 1 and 2. *Pleurotomaria pervetusta.* 3. *Cypricardia alata.* 4. *Orbicula parmulata.* 5. *Lingula cuneata.* 6 and 7. *Bellerophon bilobatus.* 8 and 9. *Cypricardia orthonata.*

The position of the *Lingula cuneata* is curious. Their beaks are all turned one way, nearly N. N. W. with a little ridge of stony matter extending beyond. Both valves are seldom, if ever found together, and the convex side of the shell is upwards, bearing evidence, as Mr. H. infers, that they have been strewed by a tide or current and lodged on some sandy bottom.

The surface of the quarries of grey sandstone at Lockport show, in connection with the above, numerous curved and often parallel ridges, believed to be wave lines which have escaped obliteration during the hardening of the sandy strata.

* By "the upper part of the mass" in this place, Mr. Hall refers to the upper part of division *third*, which moreover is near the upper part of the rock, as the *fourth* division is scarcely above six or eight feet thick.—Eds.

Ripple marks are beautifully preserved in the terminal grey mass at Medina, in connection with the *Dictuolites.*

No strata have as yet been discovered in the Western States which can be identified with the Medina sandstone.

Clinton Group. (A part of No. 5 of Pennsylvania and Virginia.)—From the variable character of the deposites embraced in this formation, it was first described under the name of the Protean group. In Pennsylvania it is known as the red and variegated shales and sandstones. Such are its predominating features, but interstratified with them are thin bedded impure limestones and iron ore.

Where it is well developed, as above the lower Genesee Falls, the following divisions are distinguishable:—

	Feet.
1. Lower green shale, - - - -	23·00
2. Oolitic, lenticular or fossiliferous iron ore, -	1·20
3. Pentamerus limestone of the Clinton group, -	14·00
4. Second green shale, - - -	24·00
5. Upper limestone of Clinton group,* - -	18·40
Total thickness of the united beds, - -	80·60

The lower green shale and Pentamerus limestone form the middle Genesse Fall; the outcropping edges of the upper shale and limestone are visible above this fall.

The belt of country occupied by the Clinton group in New York is limited. On the chart it is represented by a narrow green band running nearly east and west, south of the Medina sandstone, widest in Wayne County and near Lake Oneida, thinnest towards the west, extending from Sharon near the centre of the state into Canada.

The beds of iron ore are, in a practical point of view, the most important part of this formation. There are two of them, separated usually by about twenty feet of calcareous shale. The lower of these is most productive, and varies in thickness from six inches to two feet. The upper is only worth working at a few localities. It is supposed that this ore has originated from the decomposition of iron pyrites and subsequent infiltration, into its present position from the adjacent ferruginous beds.

These ore beds are evidently of the same nature and occupy the same geological position as the fossiliferous calcareous iron

* Hall's Report, p. 67.

ore of formation V, of the Pennsylvania survey, from which some of the best Juniatta iron is manufactured.

It appears from the New York Reports, that the ore is accessible at numerous localities and of good quality; yet it is somewhat strange that in that great and populous state, it has attracted but little the attention of the iron master; only two furnaces are enumerated in the range of this ore, the Wolcott and Westmoreland furnaces; and even these seem to be only partially supplied with ore, for Mr. Vanuxem, on page 84 of his Report, speaking of the ore in question, has the following paragraph: "The ore is very near the surface at Wadsworth's pits, and is of easy extraction. None is used, nor will much of this extensive deposite be used, so long as individual interests predominate over national or social ones; it being more advantageous to use Scotch pigs, either with a portion of the ore or by themselves, than to obtain iron from the ore, though it exists so abundantly and conveniently."

The value of the southern extension of this iron region in Pennsylvania, may be judged of from the following extract from the report of the state geologist:* "Enough is already known respecting the excellent quality of the ore, the large quantity still readily accessible, and the cheapness of the present modes of mining it, to establish a just confidence in the value of this formation as one of the *choicest ore tracts* in the state." Take note of that, New Yorkers! One of the *choicest ore tracts* in that greatest of iron countries, Pennsylvania! And why not also in your state? The formation, it is true, seems to be thicker in Pennsylvania than in New York, but it does not appear from the Reports, that there is much difference in the thickness of the ore beds in the two states.

The ore in Pennsylvania, and we presume also in New York, is often a very convenient mixture of oxide of iron and carbonate of lime; the latter just in the proportion necessary to flux the iron.

The Clinton group affords in New York, besides the oolitic iron ores, no minerals of much economical importance. Some fine crystals of quartz and chalcedony have been found in geodes originating in the group in question; also siliceous sinter, cacholong and carnelian. At some of its localities, sulphate of barytes and sulphate of lime occur in cavities in the Pentamerus and upper limestone. At Wolcott the former of these minerals is found, of a flesh red color, in the oolitic iron ore. A little pyri-

* Second annual Report of Prof. Rogers, p. 44.

tous, green carbonate and spiculæ of native copper, have been discovered in the Pentamerus rock.

Hall has observed "slightly tortuous ridges, standing out in bold relief on the surface of some of the lower strata;" these he denominated casts of mud-furrows.

The fossils of the Clinton group are various and interesting, though on account of the protean lithological character of the mass, they are not so persistent over a wide area as some of the organic remains of other members of the New York system. Fucoids are most common in the shales and shaly sandstones.

The lower limestone is remarkable for the number of Brachiopoda, of the forms here represented.

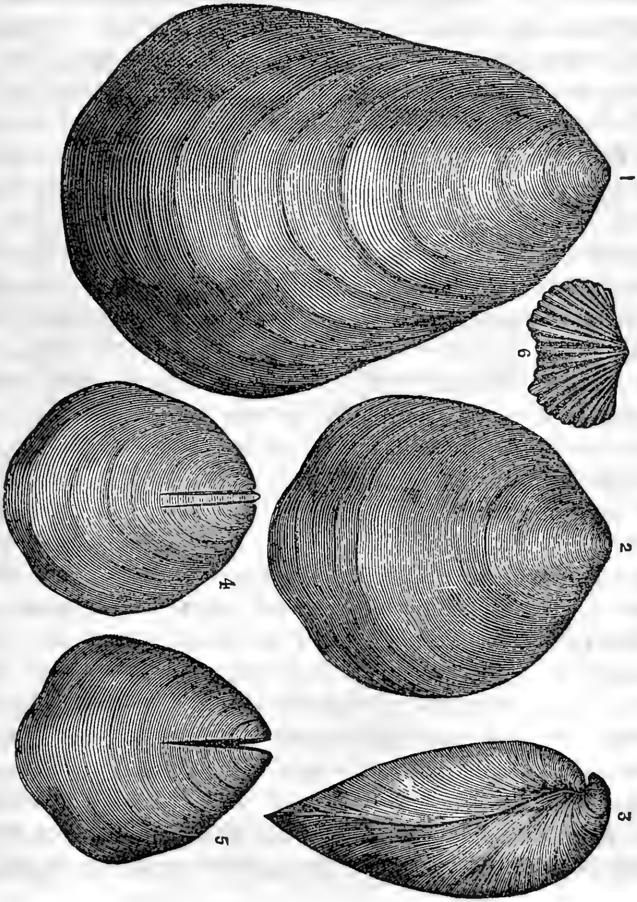


Plate 15, p. 70, Hall's Report.

Plate 15, figs. 1—5. *Pentamerus oblongus.* 6. *Delthyris brachynota.*

The preceding five figures of Pentamerus are all referred by Hall to one species. The difference of form and size he attributes to age and condition of the fossil. The species is supposed to be identical with the *P. oblongus* of the calcareous beds of the Caradoc formation of England; and the Clinton group is hence regarded as the American equivalent of that portion of Murchison's Silurian system. A species closely allied to it occurs also in the West, and the New York geologists seem to have concluded, that the strata containing it must necessarily occupy the very same geological position as the Pentamerus limestone of New York. Mr. Conrad, speaking of the Pentamerus beds in Wisconsin, affirms that when the *Pentamerus* in question is associated with chain corals, as in that territory, the strata containing them are never higher than the Clinton group of New York. But this is by no means a settled point; indeed, there are strong proofs that the Pentamerus rock of Iowa and Wisconsin is a higher member of the Protozoic system, than the Clinton group of New York. The Pentamerus and Catenipora in the northwest are associated with a variety of corals, most of them bearing a strong resemblance, and many of them evidently specifically identical with Polyparia of the Wenlock and Dudley limestones of England, which belong to the upper Silurian system; whereas the Clinton group has been placed by its describers in the lower Silurian system.

In Indiana the Pentamerus layers, though beneath, are in close proximity to coralline beds containing many of the same species of Polyparia, associated with the same Pentamerus as in the territories.

Besides the remains of the Pentamerus in question, in the Western states and territories are almost invariably internal casts, which give but an imperfect knowledge of the shell itself. Close comparison of complete fossil shells might perhaps prove the western species to be distinct from the *P. oblongus.*

Again, the evidence derived from the occurrence of the *Catenipora escharoides* is at best unsatisfactory, since it has so wide a range. In New York this chain coral extends from the Clinton group up to the Manlius water-limestone; in the West it appears to have been found by Dr. Clapp even as high as the coal formation; in England it ranges from the Llandeilo flags of the lower Silurian through all the intervening beds up to the Aymestry

limestone of the upper Silurian; but it is most abundant, and characterizes more especially the Wenlock and Dudley limestones. In Iowa and Wisconsin it is a remarkably abundant fossil in the upper magnesian Pentamerus limestone; thus, so far as this fact goes, it rather indicates that the strata containing them are upper Protozoic.

Furthermore, the Clinton group of New York has but little lithological analogy with the Pentamerus and Catenipora limestone of the northwest. The strata of the latter region are magnesian limestones, remarkably free from shaly or agillaceous intermixture; the Pentamerus rock of New York is included between very thick beds of green shale. In Indiana and Ohio the Pentamerus beds of the cliff formation, though they do not contain as much magnesia as the equivalent rocks of the northwest, are nevertheless magnesian without any intercalation of shale.*

Below are other fossils found in the limestones of the Clinton group:

Hall's Report, p. 71.

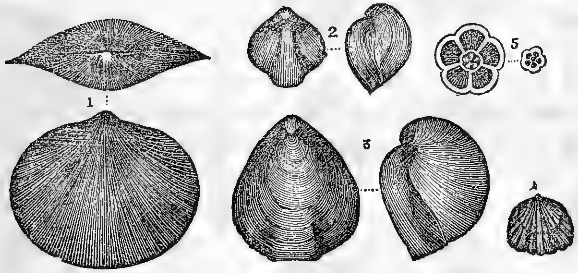


Fig. 1. *Orthis Circulus.* 2. *Atrypa congesta.* 3. *Atrypa naviformis.* 4. *Atrypa plicata.* 5. Crinoidal joint (*Actinocrinus plumosus?*) natural size and magnified.

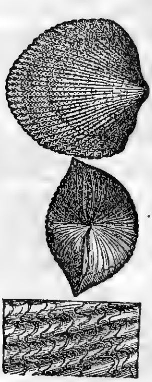
Of these the most widely distributed is fig. 5, being found throughout the western extent of this formation in New York, and also in Ohio. Fig. 2, says Hall, "appears to take the place of the *Pentamerus* at some localities, so far as regards numbers of individuals, prominence, and place in the strata."

A beautiful little semicircular *Strophomena* occurs at Rochester in the upper green shale, to which the name *S. elegantula*

* The strata discovered by Dr. Locke, containing oolitic iron and some fossils identical with those of the Clinton group of New York, lie lower than those containing the Pentamerus; they occupy the same geological position as the "flinty limestone" of his Report, i. e. immediately above the blue limestone.

has been assigned. The figure of this fossil given in Hall's Report, differs but little from the figure of the *S. sericea?* (p. 366, Vol. XLVII,) of the Trenton limestone; it is said however to have strongly marked elevated lines, with four to six fine striæ between each, which the *S. sericea* has not. These are, however, not distinctly shown in the figure. According to Hall, it bears also a considerable resemblance to *S. transversalis*, a Wenlock shale fossil. If so, it must be much more convex in one valve and more concave in the other, than the *S. sericea.*

The *Atrypa affinis*, figured below, is abundant in the upper and lower green shale. This is the lowest position of this fossil.



Vanuxem's Report, p. 88.

Atrypa affinis.

Plate 18, p. 76, Hall's Report.

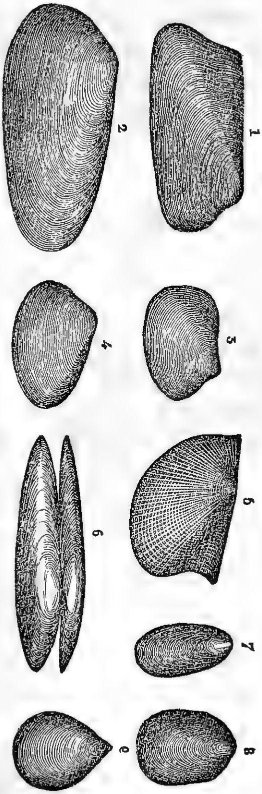


Plate 18, fig. 1. *Orthonata curta.* 2. *Nucula machæriformis.* 3. *Cypricardia obsoleta.* 4. *Nucula mactriformis.* 5. *Avicula leptonota.* 6. *Cypricardia? angusta.* 7. *Lingula elliptica.* 8. *Lingula oblata.* 9. *Lingula acutirostris.*

The forms shown in Plate 18, are found in the Wolcott ore bed, and are important, as they may serve as guides in tracing out the ferruginous band.

Vanuxem gives the following figures in his Report, as most characteristic of the Clinton group in his district.

Plate 19, p. 77, Vanuxem's Report.

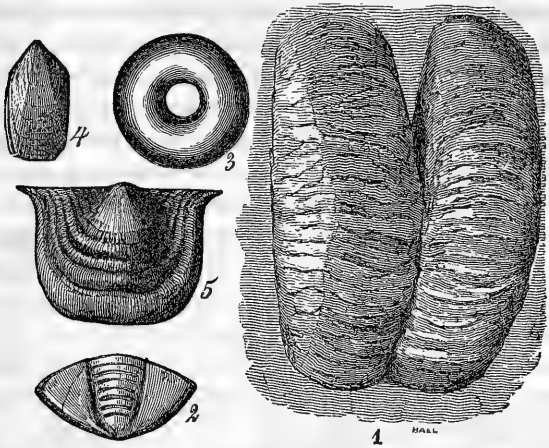


Plate 19, fig. 1. *Fucoides bilobata.* 2. Tail of *Hemicrypturus.* 3. Crinoidal joint. 4. *Lingula oblonga.* 5. *Strophomena depressa.*

Fossils resembling figs. 1 and 3, have been found by Dr. Locke in Ohio. The latter is very abundant in "the flinty stratum" between the cliff and blue limestone of Adams County; but the bilobed Fucoid much lower, in the blue limestone formation at Cincinnati. It may very possibly be a distinct species.

Niagara Group. (A part of No. 6, if recognized in the Pennsylvania survey.)—This group consists of shale below and limestone above. The latter, in the eastern part of the state, is thin, dark colored and concretionary, presenting many curious forms and appearances represented in the Reports. Westward, it gradually thickens into an important calcareous mass. From the crumbling nature of the shale beneath, an undermining action is observable wherever the group is exposed, and the capping of hard limestone at first projects in overhanging ledges; at last the poised mass, for want of adequate support, is precipitated into the abyss below. The retrocession of the falls of Niagara is due to this cause. And not only here, but over the entire belt of country where these two members of the Niagara group prevail, wherever a considerable stream has cut a channel, it at last terminates in a fall, before it winds its way to the succeeding

geological formation. Thus have been produced the upper fall at Rochester, the falls at Wolcott and at Shelbyville.

The shale is more constant in its thickness than the limestone. The former varies from eighty to one hundred feet; the latter is only thirty to forty feet in Wayne County; seventy to eighty feet at Rochester, and one hundred and sixty four feet at Niagara Falls.

The Niagara group as well as the Hamilton group, are both colored light blue on the geological chart, but the former is a shade darker and lies further north, and comprises a narrower, wedge-shaped tract of country, south of and parallel to the Clinton formation; broadest in the west at the Niagara River, and running out in the east in Litchfield township near the corner of Herkimer and Oneida counties, so that its eastern termination falls a little west of the preceding group.

At the outcrop of the shale and underlying the Medina sandstone, the clay of the former and sandy products of the latter afford a soil of wonderful fertility, admirably adapted to the growth of wheat; sometimes however the clay predominates, and then the soil is too stiff and retentive. The soil over the limestone is for the most part loamy, with a rapid drainage through the fissures of the limestone rock.

Though there is some variety of minerals in this formation, none are found in sufficient quantity to be of much economical value. The shale affords in sheltered situations, sulphate of magnesia, sulphate of alumina, muriate of soda. Nodules of gypsum are also found replacing organic substances. Iron pyrites is very common throughout the shale and occurs also in the limestone, and near their junction some green carbonate of copper has been found. The limestone has yielded some fine specimens of calcareous spar crystallized in scalene dodecahedrons; also pearl spar, brown spar, selenite, sulphate of strontian, anhydrite, and occasionally fluor spar, blende and galena. The latter in some situations appears to be distributed in minute veins in the calcareous beds: during the excavations for the Erie Canal at Rochester, several hundred pounds of sulphuret of lead were found in one cavity.

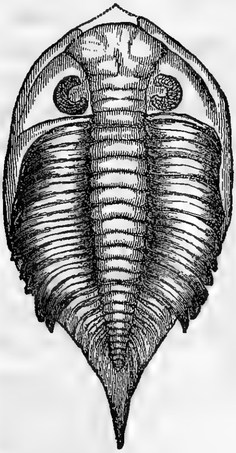
Penetrating the calcareous spar lining imbedded geodes, are long prismatic hair-like crystals, which Dr. Beck regards as achmite. At the Cold Spring quarries two miles south of Lockport, in cavities of encrinital layers, native sulphur is not uncommon.

Huge beds of tufa are formed where the springs issue between the limestone and shale. Springs issuing from this formation are occasionally charged with sulphuretted hydrogen.

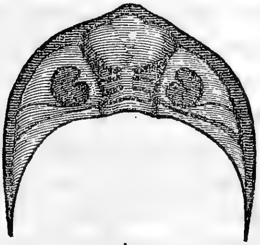
The Niagara group is every where highly fossiliferous, particularly the shale. Shells, trilobites, and crinoidea, are most abundant in the shale; and corals in the limestone. Already six species of trilobites, nine species of crinoidea, and about as many mollusca, have been recognized as belonging exclusively to the shale. The corals are for the most part much decomposed, which makes it difficult to distinguish the species.

The following are some of the most common trilobites of the shale.

1.



2.



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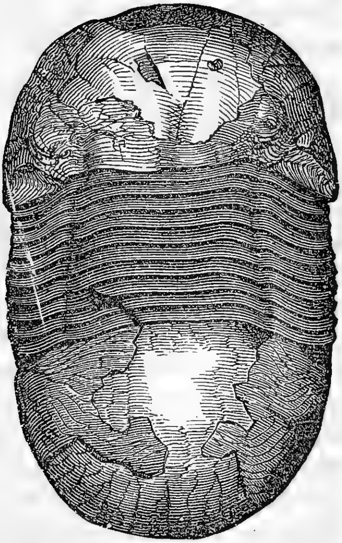


3.

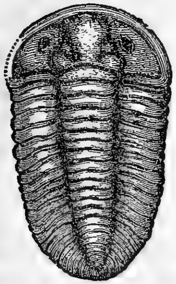


Fig. 1. *Asaphus limulurus.* 2. Head of *Asaphus limulurus.* 3. *Calymene Niagarensis.* 4. *Bumastis Barriensis.*

Fig. 1 is the most abundant trilobite at Lockport; it is closely allied to the *A. longicaudatus* of the Wenlock shale of England, differing from it only in having the tail less attenuated and having fewer ribs in the post abdomen. We are not aware that this species has yet been found in the West.

The *Calymene*, fig. 3, has until lately been referred to the *C. Blumenbachii*, and so also has a Trenton species, (*C. senaria*,) but these are probably so many distinct species. The Niagara *Calymene* is more obtuse, according to Hall, in the posterior angles of the buckler than the *Blumenbachii*, and has fewer articulations (13) in the back; the protuberances of the middle lobe are less prominent in the Niagara species than in the *Blumenbachii*. Casts of a *Calymene* have been found in the "cliff formation" of the West, bearing a strong analogy with the Niagara species. These casts do not however, exhibit any terminal margin-band in front of the buckler, and the surface of the buckler appears quite smooth and not covered with pustules, as is the case with the *C. Blumenbachii*, and appears also to exist on the Niagara species, so far as can be judged from the figure given in the New York Reports.

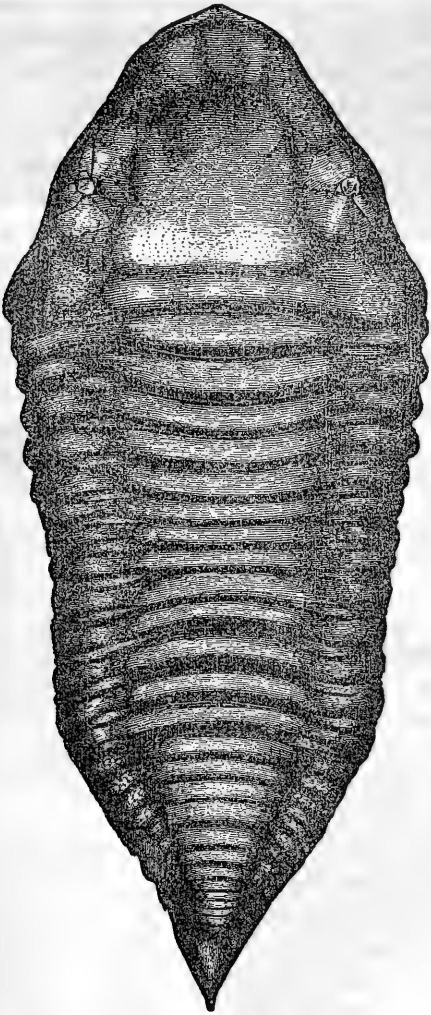
Figure 4, is supposed to be identical with the *Bumastis Barriensis* of the Wenlock limestone. It is known at Lockport, where it is found in the shale, as the "double-headed trilobite."

The magnificent species, *Homalonotus delphinocephalus*, is also a common trilobite at Lockport.

It is regarded as the same species figured in Murchison's Silurian Researches under this name, and found in the upper beds of the Wenlock limestone. That author has the following remarks regarding the identity of the English and American species. "As I can discover no difference between our *Homalonotus* and the American *Trimerus delphinocephalus*, (Green,) except in size, (the latter being very diminutive,) I have retained the specific name of the American author, while I adhere to the generic name of König, which was applied to bodies of this form before the publication of Dr. Green." The specimens of this species found at Lockport are from eight to twelve inches in length; they cannot, therefore, be much smaller than those found near Dudley Castle in England.

Hall says this trilobite has been confounded with the *Dipleura Dekayi* of the Hamilton group. He asserts that the nature of

Plate 34, p. 103, Hall's Report.



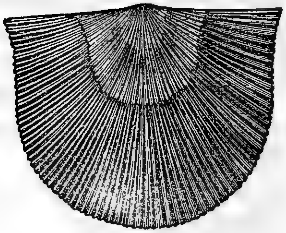
Homalonotus delphinocephalus.

the matrix enclosing the two is very different, and though there is some resemblance in the heads of the two species, he considers them quite distinct.

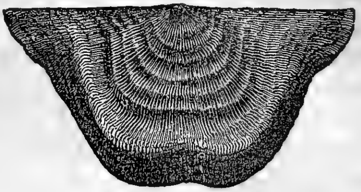
The following are the most common forms of *Strophomena* in the Niagara shale.

Plate 35, p. 104, Hall's Report.

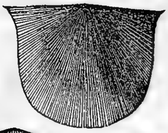
1

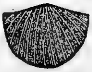


2

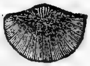


3





4



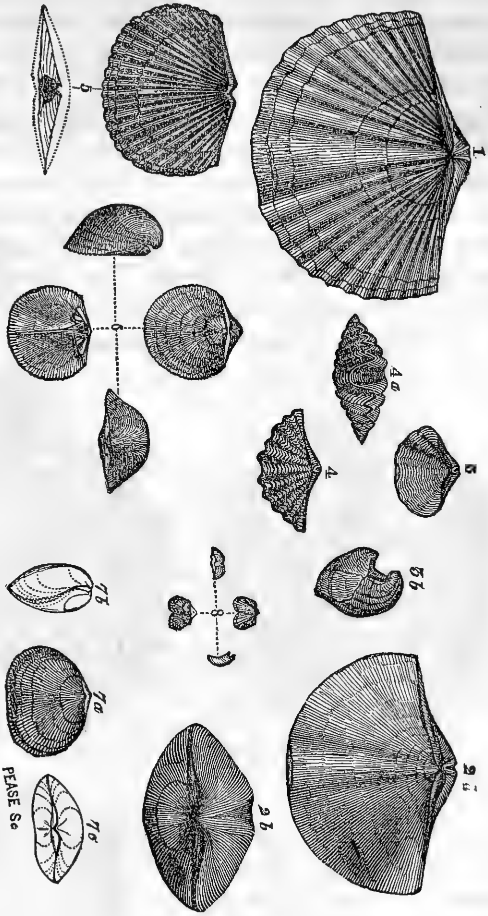
Pl. 35, fig. 1. *Strophomena subplana.*
2. *S. depressa*, (lower valve.)
3. *S. striata.*
4. *S. transversalis.*

The deflected portion of fig. 2 is usually not so long, nor the undulations so numerous as in Murchison's figure of the same name, nevertheless Hall thinks the English and American fossil the same species, since this shell of different ages, from the same rock, has variations of the same kind. There is a wrinkled *Strophomena* found in the West which bears considerable analogy to this same *S. depressa.* The hinge-line of the New York species is however more prolonged, and terminates in sharper angles; the deflected portion probably of less area, and the undulations of the flat surface fewer. The western fossil here referred to, occurs in the upper part of the blue limestone and marlite, (rather lower than the beds supposed to be equivalent to the Niagara group,) but Hall says the New York species commences in the Clinton group, yet it is most abundant in the Niagara group. The western fossil is known as the *S. undulata.** Both figs. 1 and 3, resemble species found in the blue limestone of the West, but we are not prepared to decide upon identity without comparing the fossils themselves. The New York specimens of fig. 4, differ from Murchison's figure of the same name only in being a little "smaller and less prominently ribbed."

* The fossil referred to by Dr. Owen is doubtless the *Strophomena* (*Leptæna*) *tenui-striata*, a species from the Llandeilo flags of Wales, and common in the Trenton limestone of New York.—Eds.

The Delthyris and Orthis, most characteristic of the group under consideration, are embraced in this wood cut.

Plate 36, p. 105, Hall's Report.



Pl. 36, fig. 1. *Delthyris Niagarensis.* 2 and 2b. *D. radiata.* 3 and 3b. *D. staminea.* 4 and 4a. *D. decemplicata.* 5. *Orthis flabellula.* 6. *O. canalis.* 7. *O. hybrida.* 8. *Delthyris sinuata.*

Fig. 1 is "peculiarly typical of the group." Fig. 2 "ranges from the ore beds of the Clinton group to the Niagara limestone," and is considered identical with a Silurian species. So also is fig. 5. A shell "apparently identical is associated with the *Pentamerus oblongus* in the Clinton group;" it differs only "in the number of radii, and the less convexity of the lower valve, from the *O. callactis* of the Caradoc of England."

Fig. 6 is very abundant in the shale of this group; it differs only in size from a Swedish specimen, and is very closely allied,

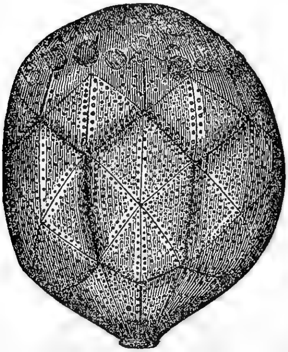
as previously remarked, to a western fossil, *Orthis* (*striatula?*) found in the blue limestone, perhaps a little more convex. According to Hall, there is a shell almost precisely similar in form, but more robust, in the Delthyris shaly limestone. Fig. 7 cannot be distinguished from the *O. hybrida* of the Wenlock formation of England.

Atrypa affinis of a rather flatter form than the figure already given under the head of Clinton group, is common at all the localities of the Niagara shale. "There are probably as many species of crinoidea well identified from the Niagara shale, as from all the other rocks of the New York system."

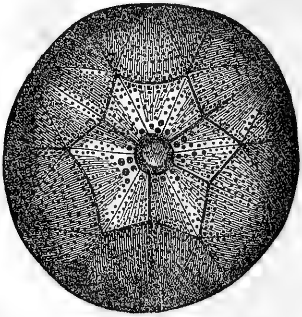
The fossil represented in figures 1 and 2 below, (*Caryocrinus ornatus*,) is found in great numbers at Lockport, and is known there by the name of the "petrified walnut."

Plate 41, p. 111, Hall's Report.

1.



2.



3.

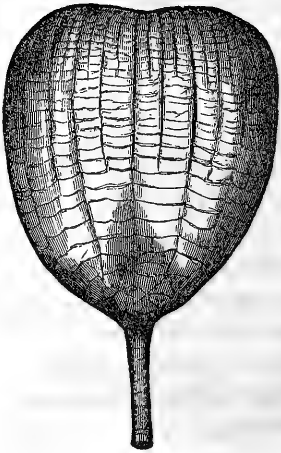


Figure 3, (*Cyathocrinites pyriformis.*) It is supposed to be identical with the *Cyathocrinites pyriformis* of the Wenlock limestone.

Corals occur abundantly both in the shale and limestone. Those in the shale are "usually referable to the genera *Retepora* and *Fenestella*;" those of the limestone are often stone-building corals.

It is much to be regretted that so few figures of the Niagara corals are given in the Report, since the organic remains of the western strata referable to the same geological epoch are almost exclusively of this class, and figures of the New York species would serve as excellent guides in settling some disputed points of identity. We presume, however, that the forthcoming volume on palæontology will supply this deficiency.

The following is a list of the remaining fossils of the Niagara group, taken from Hall's Report.

Atrypa imbricata, A. (species undetermined), *A. cuneata, A. nitida, Orbicula? squamiformis, O. corrugata, Lingula lamellata, Avicula emacerata, Euomphalus hemisphericus, Cornulites arcuatus, Orthoceras annulatum? Conularia quadrisulcata.*

Hypanthocrinites cœlatus, H. decorus, Marsupiocrinites? dactylus.

Platynotus Boltoni, Asaphus Coryphæus.

Catenipora escharoides, C. agglomerata, Porites —— ?

Gorgonia? retiformis, Gorgonia? —— ? *Isis?*

But little doubt is entertained that the Niagara shale and limestone are equivalent to the lower members of the upper Silurian rocks of England. Hall, speaking in general terms of the corals and other fossils of the calcareous bands in the upper part of the Niagara shale, has the following remark. "The perfect similarity of these with specimens from Dudley in England, together with the identity of many of the organic forms, renders the conclusion unavoidable that the two are formations of the same age." The lithological character of these New York and Silurian strata is wonderfully alike.

The coralline beds of the magnesian limestone formation of Iowa and Wisconsin, as well as the coralline beds of the falls of the Ohio, will doubtless prove to be their western equivalents, though the lithological resemblance is not so apparent.

It is worthy of remark, "that the Wenlock limestone contains some forms identical with those of the lower limestones of the Helderberg division, which in New York are separated by the Onondaga salt group, one thousand feet in thickness," yet, as Hall suggests, "we can account for this apparent difference upon the supposition that the latter formation does not exist in England, and that the higher limestones come down upon the lower, or equivalent of the Niagara, and the whole are recognized as one formation."

The following is a list of the species which Hall considers common to the Wenlock and Niagara formations.

Strophomena transversalis, *S. depressa*, *Orthis canalis* or *elegantula*, *O. hybrida*, *Delthyris radiata*, *D. sinuata*, *Atrypa affinis*, *A. imbricata*, *A. cuneata*, *Conularia quadrisulcata*, *Bumastis Barriensis*, *Homalonotus delphinocephalus*, *Hypanthocrinites decorus*, *Cyathocrinites pyriformis*. There must, doubtless, be many species of corals common to the two formations. According to the geographical arrangement, the Ontario division terminates upwards with the Niagara group; but in the chronological table this group forms the lower part of the middle division. D. D. O.

(*To be continued.*)

ART. X.—*Observations made at New Haven, Conn., on the Shooting Stars of the August Meteoric Period, in* 1844; communicated by E. C. HERRICK.

THE nights of the 1st, 2d, and 3d of August, 1844, were too cloudy here to permit any satisfactory celestial observation. The evening of the 4th was beautifully clear:—watching alone for twenty minutes ending 10 P. M., I saw *five* shooting stars. The evening of the 5th was like the previous one: Mr. F. Bradley and myself watched twenty five minutes, ending 10h. 5m., and saw but *ten* of these meteors. These periods are evidently too short, but may perhaps serve to show that no great increase in number was yet observable. The night of the 6th was in part stormy, and afforded no opportunity for a look-out. The evening of the 7th was somewhat hazy. Mr. W. M. Smith watched from 9h. to 10h., and saw *seven* meteors. The evening of the 8th was nearly clear. Between 9h. and 10h. I noted in the N. E. quarter *fifteen* meteors, more than half with trains, but none very conspicuous: during the same hour at another station, Mr. S. noted *twenty one*, his quarter being more easterly.

The evening of the 9th was mostly overcast as late as eleven o'clock. At Nantucket, Mass., the sky was clear for about an hour, (9 to 10?) and two observers saw "upwards of thirty meteors within a period of forty five minutes." A faint aurora in the form of streamers, is reported by Mr. William Mitchell as having been visible during the hour.

In spite of the apparent hopelessness of the case here, a corps of observers (consisting of Messrs. F. Bradley, E. Norton, E. A. Raymond, Wm. M. Smith, and Wm. J. Weeks) took their stations on the summit of the State Hospital in this city, intending to remain until dawn. Their perseverance received its reward, in part at least, as the following results will prove. Four only were on duty at once as observers; and the meteors were reckoned in the quadrant in which they were first detected. Up to 11h. 20m. the sky was wholly overcast.

Aug. 9. 11h. 20m. to midn.,	N.	13		Time 40m.; during which on an average, 0·75 of the sky was overcast.
	E.	6		
	S.	6		
	W.	18		
		—	43 meteors.	
Midnight to 1h. A. M. (10th,)	N.	25		Time 60m.; first 30m. sky about ·62 overcast; last 30m. sky about ·25 overcast.
	E.	19		
	S.	20		
	W.	24		
		—	88 meteors.	
1h. to 2h.,	N.	30		Time 60m.; sky about ·37 cloudy.
	E.	27		
	S.	45		
	W.	37		
		—	139 meteors.	
2h. to 3h.,	N.	38		Time 60m.; sky about ·80 cloudy.
	E.	26		
	S.	14		
	W.	19		
		—	97 meteors.	
			367 in all.	

The evening of the 10th was wholly overcast, up to 10 o'clock at least, and the prospect of any change in the weather was so slender that the watch was abandoned. The next morning I ascertained that the clouds dispersed sometime after midnight. As a partial supply of the deficiency, we have a letter addressed to the Editors, by Prof. S. R. Williams, giving his observations during four and a half hours, ending 1 A. M. of the 11th. The letter will be found further on.

The night of the 11th was clear. Observers:—Messrs. H. C. Birdseye, J. A. Dana, J. C. Mullikin, W. M. Smith. J. B. Walker, and myself. We stationed ourselves on the Hospital a little before 10 o'clock. During most of the night there was but one observer to a quadrant; and on the whole, I estimate that the number of meteors observed was not more than a tenth greater than would have been noted by four observers. Due care was taken, as heretofore, to prevent the same meteor from being reckoned more than once. The following summary shows the number of different shooting stars observed.

Aug. 11.	9h. 50m. to 11h.,	N. E.	33		
		S. E.	21		
		S. W.	21		
		N. W.	21		
			—	96	
	11h. to midnight,	N. 11° W. to E.	51		
		S. E.	23		
		S. W.	18		
		N. W.	13		
			—	105	
	Midnight to 1 A. M. 12th,	N. E.	45		
		S. E.	33		
		S. W.	25		
		N. W.	15		
			—	118	
	1h. to 2h. A. M. 12th,	N. E.	47		
		S. E.	45		
		S. W.	30		
		N. W.	29		
			—	151	
	2h. to 3h. A. M. 12th,	N. E.	39		
	three observers:	S. E.	58		
		S. W.	35		
		N. W.	20		
			—	152	
				—	622

In regard to the general characteristics of the meteors seen this night, and their point of apparent radiation, I remarked no special difference from former years. The observations of 1839 and 1840, (this Journal, Vol. XXXVII, p. 328, and Vol. XXXIX, p. 330,) may be consulted as coinciding in these respects very nearly with the present.

On taking my post at 9h. 50m. (11th) I was gratified with the sight of five or six streamers of the *aurora borealis*, about 4° high on the northern horizon. These vanished in about five minutes. Again, at about 10h. 50m., appeared for a few minutes a short solitary streamer. No other indications of the aurora borealis were visible throughout the night. Eight years ago we should have thought so meagre a display hardly worth notice; but as the phenomenon has now become comparatively rare, and no exhibition of it had with certainty been seen since the 22d of May previous, its recurrence even on a small scale, just at this period, seems deserving of some attention.

The morning of the 13th was clear. Messrs. C. H. Meeker and G. C. Murray, watching from 1h. 50m. to 3h. A. M., saw *forty six* meteors, viz. in N. 15, S. E. 31. The evening of the 13th was overcast as late as 11h., and doubtless much later; but no observation was attempted after midnight.

The foregoing observations, although incomplete, are sufficient to show that the *meteoric sprinkle of August* did recur this year in copiousness not far inferior to any display since 1837. After making a fair allowance for the meteors concealed by clouds, and assuming the average rate at that time of day at forty per hour—we may conclude that the number actually falling on the morning of the 10th, (from midnight to 3 A. M.) was probably not less than six times this average. Whether the morning of the 11th was more fruitful than that of the 10th, we cannot determine; the present being leap-year, there was perhaps no great difference between the two. The next morning shows a decided diminution.

As no report from this place has, I believe, yet been made relative to the August meteoric period in the year 1843, I will here state, that during the whole time the sky was remarkably cloudy, and afforded scarcely any opportunity of making the usual observations.

I take this occasion to correct two errors in my paper on the *star-showers of former times*, in Vol. XL of this Journal, viz. p. 352, line 11th from bottom, for *Saturday* read *Friday;* p. 356, line 12th from bottom, for *Victor* read *Secundus.*

Yale College, October, 1844.

Letter to the Editors from S. R. Williams, Professor of Natural Philosophy and Chemistry in Jefferson College.

Jefferson College, Canonsburg, Pa., August 30, 1844.

Gentlemen—On the night of the 10th inst. we had a fine display of meteors; the entire absence of clouds and moonlight giving peculiar facilities for observation.

At half past 8 P. M. I took a position which commanded a view of the northeastern portion of the heavens; observed carefully and without interruption until 1 A. M.—in all four and a half hours. Within this time, and in the section of the visible heavens above mentioned, I counted *one hundred and seventeen* meteors. They differed much in splendor and in duration of appearance—the paths of some being not more than two or three degrees in length, while others were from twenty to thirty degrees. The "radiating point" was in the direction of *Cassiopeia*, and followed that constellation in its progress from the horizon to its meridian altitude. A few "stragglers" started from other points; but the courses of about one hundred were from *β Cassiopeiæ*, towards the constellations *Cepheus*, *Lacerta*, and *Andromeda*. Towards the close of the observations, the "radiating point" seemed to be falling to the southeastward of *Cassiopeia* and to approach the head of *Perseus*, as though its progress were not quite equal to that of the former constellation.

An intelligent friend who was abroad until a late hour of the same night, stated that he observed meteors in great numbers in all parts of the heavens, but that they were particularly splendid and numerous towards the southwest.

On the evenings of the 9th and 11th also, a few of unusual brilliancy were seen, but they were much less numerous than on the night of the 10th.

Respectfully yours,

S. R. Williams.

ART. XI.—*Notice of some New Localities of Infusoria, Fossil and Recent;* by J. W. BAILEY, Prof. Chem. U. S. Military Academy.—(with a plate.)

THE amount of material for microscopic examination which has been placed in my hands during the past year is so great, that to do full justice to its scientific value would require a large volume with costly engravings, for the preparation of which I have neither time nor means to devote. I must therefore at present content myself with the following brief notices, accompanied by outline sketches of some of the more remarkable forms. Specimens from most of the localities have been sent to Ehrenberg, and the interesting results of his examination of one of the specimens have fortunately been received in time to be incorporated in this article. His observations upon the specimens from the other localities will be published as soon as received.

I. *Fossil Infusoria from the Oregon Territory.*—In examining some specimens of earthy matters from the tertiary formations of Oregon, which were kindly furnished me by James D. Dana, Esq. late of the United States Exploring Expedition, I was greatly pleased to find one mass of what appeared to be fossil fluviatile infusoria. The mass was of a grayish white color, of but little density, and contained the infusorial forms in a state of fine preservation. The total absence of the genera Coscinodiscus, Actinocyclus, Actinoptychus, and others, which are only found in deposits from salt or brackish waters, convinced me that the mass was probably of fluviatile origin. It was then of interest to see how this group of fossil fresh-water forms from northwestern America compared with those of the northeastern parts of the same continent. I have found very few species in common, and these occurred very sparingly in the Oregon specimen. Among these were *Navicula viridis* and *Cocconema cymbiforme*, both common species in this region, but quite rare in the Oregon specimen.

The most remarkable forms from Oregon are the following, for which Ehrenberg's names will soon be furnished.

1. *New genus?* allied to *Terpsinoë?* (See Plate IV, figs. 1, 2, 3, 4, end views, and 5, side view.) This occurs in plates of various degrees of convexity, presenting on the flattened lateral

surfaces a series of marks somewhat like those in Terpsinoë, which Ehrenberg has compared to notes of music. The end view shows considerable variety in the outline, but always presents a series of transverse bars or ribs, which in the most rounded specimens resemble the parallels of latitude drawn upon the map of a hemisphere. Fossil at Oregon; common.

2. *Surirella* ——, *n. sp.?* (Fig. 6.)—This elegant species of Surirella is distinguished by its elliptical outline and the very large ribs or folds of its undulated margin. Fossil at Oregon; rare.

3. *Gallionella* ——, *n. sp.?* (α). (Fig. 7.)—This species of Gallionella is remarkable for the size of its frustules, which greatly exceeds that of any known species of the genus, being often three times larger in diameter than *G. moniliformis.* The outer shell appears to be very minutely and irregularly punctate. The outline of the inner cavity, as seen through the shell, resembles that of a bell-crown hat. The length of a frustule is about equal to its diameter. Fossil at Oregon; common.

4. *Gallionella* ——, *n. sp.?* (β). (Fig. 8.)—This species is much smaller than the preceding, and has the surface of the frustules covered with granules, so arranged as to give longitudinal and transverse lines. The length of a frustule is about equal to its radius. Fossil at Oregon; common.

5. *Gallionella* ——, *n. sp.* (γ). (Fig. 9.)—This species may possibly be a young state of the last, (β); but it appears distinct in its smaller size, and by the length of the individuals being often equal to their diameter. The granules present longitudinal and transverse rows, as in the preceding species. Fossil at Oregon; common.

Besides the above forms, there were also detected spiculæ of Spongillæ, a few minute species of Navicula, Cocconeis, &c.

Although I have little doubt that the above forms are new, I waive the right of naming them myself, in order that they may be examined by Ehrenberg, compared by him to the forms of other regions, and finally introduced into science by his undoubted authority.

With regard to the geological position of the above fossils, I can only state that the specimen in which I detected them was labelled by Mr. Dana as coming from the "Tertiary of Oregon," and that a considerable mass of the same earth is placed with

this label among the geological specimens brought home by the Exploring Expedition. The other specimens which accompanied it, contained marine shells. It is therefore probable that the tertiary of Oregon may, like that of Europe, contain alternations of fluviatile and marine deposits which have never been detected in the tertiary formations of the eastern portions of the United States. That the deposit in question is an ancient one, and possibly of extinct species, is rendered probable by the fact that none of the species agree with the recent infusoria found by myself entangled in a mass of Confervæ attached to a Unio from Fort George, Columbia River, neither do they agree with any of the recent fresh-water forms figured by Ehrenberg as coming from any part of North America. The recent forms on the Unio from Columbia River much resembled those from the eastern portions of the United States, and among them were the following.

Gomphonema minutissimum, *Gallionella aurichalcea*, *Eunotia Westermanni*, *Synedra ulna*, *Cocconema cymbiforme*, one species of *Fragillaria*, a minute *Cocconeis*, and a few spiculæ of *Spongilla*.

II. *Fossil Infusoria from the Bermuda Islands.*—Some months ago I received from M. Tuomey, Esq. of Petersburg, Va. a fine specimen of infusorial earth, labelled "*Tripoli from Bermuda*," which he requested me to examine, and to inform him if the forms which it contained were known to microscopic observers. The only information with regard to the history of the specimen, which I have yet been able to obtain is, that Mr. Tuomey received it with its present label from some mineralogical correspondent, and that he has no doubt that it came from Bermuda. The belief that this is the true locality is confirmed by the examination of the specimen itself, which presents such a group of microscopic forms as might be expected to occur at Bermuda—numerous decidedly American forms being mingled with others which have never before been detected at any locality.

Finding that this matter was uncommonly rich, and a perfect mine of beautiful *nondescript* forms, I determined at once to place it in the hands of Ehrenberg, as the *only* person now qualified to compare the species with those of all other parts of the world, and to decide upon their novelty. I accordingly transmitted to him a good supply of the earth from Bermuda, accompanied by outline sketches of some of the forms which appeared

to me to be most novel and interesting; and requested him to name and describe the species. This request he has kindly complied with, and in a letter dated Berlin, Aug. 10, 1844, he has furnished me the names for the forms whose outlines I had sent him, and also with the monthly report of the Berlin Academy for June, 1844, which contains a list of 138 species, which he has detected in the Bermuda Tripoli, together with short descriptions of 9 new genera and 58 new species.

It is but justice to Ehrenberg to state, that he has given me ample credit for every fact, however unimportant, with which I have furnished him.

From Ehrenberg's report and letter above mentioned, and the reference he makes to drawings of which I retained duplicates, I have been able to identify most of the forms which he describes, many of which are so remarkable that I believe the following notice of them, accompanied by sketches of my own, showing the most important generic characters, will not be unacceptable to naturalists. I have also included the characters of some new genera founded by Ehrenberg on forms previously included under groups from which they are now very properly separated. Many of these forms are of American type, and therefore a knowledge of them will be useful to students of our fossil infusoria.

1. "CRASPEDODISCUS, *nov. gen.*—Animal e Bacillariis Naviculaceis liberum. Lorica simplex æqualiter bivalvis silicea orbicularis non concatenata, superficie cellulosa, præter cellularum radiantem ordinem, non radiata nec septata, sed margine structuræ diversæ tumido solubilique late prætexta."

The forms of this beautiful genus resemble Coscinodisci surrounded by a distinct tumid margin of cells much larger than those upon the disc.

A portion of *Craspedodiscus elegans* from Bermuda is shown in fig. D. To the same genus is now referred the *Pyxidicula Coscinodiscus*, Ehr. which occurs fossil in Virginia.

2. "HELIOPELTA, *nov. gen.*—Animal e Bacillariis Naviculaceis liberum. Lorica simplex æqualiter bivalvis silicea orbicularis (non concatenata?) intus sepimentis imperfectis in loculos radiantes extus alterne impressos divisa, centro lævi anguloso, aperturis sub margine tot quot radii adsunt magnis, spinulis in utroque latere sub margine crebris erectis oppositis."

These truly elegant forms have the habit of Actinoptychus, but in addition they have near the margin a row of lateral spines, (somewhat like the processes of Eupodiscus, but far more numerous,) which probably connect the animalcules together in the young state. By a happy idea, Ehrenberg has dedicated the different species of this genus (which must always be a favorite among lovers of the microscope) to persons distinguished in the history of microscopic research. The species with *six* radiant septæ and *three* elevated radiant portions, is named *Heliopelta Metii*, after Jacob Metius, to whom Ehrenberg ascribes the discovery of the microscope in 1606. The species with *eight* septæ and *four* elevated portions, represented in fig. A, is called *H. Leeuwenhoekii*, in honor of Leeuwenhoek, who discovered animalcules in 1675. To Euler, for his researches upon achromatism in 1757, is given the species *H. Euleri*, with *ten* septæ and *five* elevations. To Selligue, for improvements in the structure of the microscope in 1823, is given the species *H. Sellìgueii*, with *twelve* septæ and *six* elevations. And Ehrenberg suggests that new species may hereafter be dedicated to Dollond for his achromatic inventions, and to Otto Müller for his microscopic researches. It is to be hoped that some species worthy of bearing the name of the greatest microscopic observer of the present age may be added to this list, as *H. Ehrenbergii.*

The different species of Heliopelta are very abundant in the Bermuda Tripoli, and have not yet been noticed at any other locality.

3. "Omphalopelta, *nov. gen.*—Animal e Bacillariis Naviculaceis liberum. Lorica simplex æqualiter bivalvis silicea orbicularis (non concatenata?) intus sepimentis imperfectis in loculos radiantes extus alterne impressos divisa, centro lævi, aperturis obsoletis, spinulis in utriusque lateris summo margine raris erectis oppositis."

This genus has the habit of Actinoptychus and Heliopelta, but differs from the former in the presence of lateral spines, and from the latter by the small number of these processes. The species of these three genera often closely agree in their form as well as in the number of their radii and cells, but the character of the spines will always distinguish them.

4. "Systephania, *nov. gen.*—Animal e Bacillariis Naviculaceis liberum. Lorica simplex æqualiter bivalvis silicea orbicularis (concatenata?) Valvularum testa cellulosa nec radiata nec septata, corona

spinularum aut membranacea erecta externa in ipso cujusvis valvulæ disco, (nec in ipso margine.)"

This genus has the habit of *Coscinodiscus lineatus*, but with lateral crowns, which in the young state connect two individuals.

5. "Sceptroneis, *nov. gen.*—Animal e Bacillariis Echinelleis? affixum? Lorica simplex æqualiter bivalvis silicea stiliformis compressa, non concatenata, cuneata, (viva facile pedicellata.) Sutura laterum utriusque valvæ longitudinalis media, umbilicus nullus."

The only species, *Sceptroneis Caduceus*, is represented in fig. 11. It resembles a Gomphonema, but wants the lateral umbilicus. In the fossil state it is impossible to decide whether it was fixed to a pedicel when living. It occurs in myriads in the Bermuda Tripoli.

6. Dictyopyxis, *nov. subgen.*—This subgenus is formed to include those species of the old genus Pyxidicula which have a cellular surface. Pl. II, fig. 2, in Vol. xlii, of this Journal, represents a species from Richmond, Va. now called *Dictyopyxis cruciata.*

7. "Mastogonia, *nov. gen.*—Animal e Bacillariis Naviculaceis liberum. Lorica simplex (inæqualiter) bivalvis, non concatenata, valvis siliceis angulosis mammiformibus, basi orbiculari, umbilico inermi. Valvularum membrana continua integerrima nec cellulosa, angulis radiantibus."

These forms, which were formerly placed in the genus Pyxidicula, may be recognized by having an orbicular base, connected on each side by radiant lines, with an unarmed central and elevated umbilicus, and by having a smooth surface. To this genus is now referred (without change of specific names) the two species *Pyxidicula Oculus-Chamæleontis* and *P. Actinoptychus*, Ehr. from Virginia. A species, *Mastogonia heptagonæ*, Ehr. is represented in fig. 12. The number of radiant lines in this genus varies very much, and Ehrenberg states that it is sometimes different on the two sides of the same individual.

8. Stephanogonia, *nov. gen.*—This genus has the characters of Mastogonia, but in addition has also a row of projecting spines around the umbilicus. Ehrenberg describes two species, the first, *S. quadrangula*, discovered by himself, and the second, *S. polygona*, founded on an outline sketch which I sent him of a form noticed by myself in the Bermuda Tripoli. This is represented in fig. 13.

9. Stephanopyxis, *nov. subgen.*—This group includes those Pyxiculæ which have turgid bivalve forms with a cellular surface, bearing in the middle of the valves a crown of small teeth, prickles, or a membrane. *Pyxidicula aculeata* is an example.

10. Xanthiopyxis, *nov. subgen.*—These forms are Pyxidiculæ with bristles, setæ, or wings. They have the habit of Xanthidium and Chætotyphla, but are bivalved and siliceous. *Xanthiopyxis oblonga* is shown in fig. 14; a similar form occurs at Piscataway, Md.

11. "Hercotheca, *nov. gen.*—Animal e Bacillariis Naviculaceis liberum. Lorica simplex inæqualiter bivalvis silicea turgida, valvularum membrana continua nec cellulosa, sub cute, utplurimum nervosa, aut sub setis liberis cutis locum tenentibus permanentibusque dividua. Hinc corpuscula in volvularum singularum contiguo summo margine setis aut membranis oppositis coronata et involuta tanquam obvallata apparent.

"Hæ formæ Gallionellarum more silicea sed non decidua sub cute sponte dividuntur."

One species only is described by Ehrenberg. The characters are these:

"*H. mammillaris*, testulæ valvulis lævibus basi media setis oppositis simplicibus fere 20, mammillas superantibus ipsi margini insertis obvallata. Diameter, $\frac{1}{68}'''$. Bermuda."

12. "Periptera, *nov. gen.*—Animal e Bacillariis Naviculaceis liberum. Lorica simplex inæqualiter bivalvis silicea compressa. Valvularum testa simplex continua, nec cellulosa. Una valvula turgida nuda, altera alata aut cornuta, cornibus interdum ramosis extremo margini affixis."

The forms of this genus are allied to those of the genera Rhizosolenia and Dicladia, but Rhizosolenia has one central horn, and Dicladia has two, which are also near the centre. Hercotheca differs by the turgid uncompressed form. To the genus Periptera are now referred (without change of specific names) the fossil forms from Virginia, which were described as *Dicladia Capra* and *D. Cervus*, Ehr. I presume that the forms represented in figs. 15, 16, and 17, which I have found frequently in the Bermuda Tripoli, are species of Periptera.

Besides the above genera, Ehrenberg also describes many novel *species* from Bermuda belonging to genera previously known; among the most remarkable of which are the following; to Eh-

renberg's descriptions of which I have added a few remarks, with references to outline sketches drawn by myself.

1. "*Chætoceros? Bacillaria.* (Fig. 18.)—Testula Bacillari ter quaterve latiore quam alta in utroque fine truncata et cornibus duobus mediis longis filiformibus instructa. Diam. $\frac{1}{72}'''$? Bermuda." *Ehr. l. c. p.* 18.

2. "*Chætoceros? Diploneis.* (Fig. 19.)—Testula media constricta utroque fine rotundato, habitu Diploneidis cornibus filiformibus in utroque fine mediis. Diam. $\frac{1}{80}'''$ sine cornibus. Bermuda.

"Utramque formam Prof. Bailey primus observavit et delineavit. *Ch. Bacillarium* ipse non vidi, altera in comissa terra mihi quoque obviam facta est. Chætocerotes e mari australi petiti æque lati ac longi, aut longiores quam lati sunt et catenatim vivunt, cornibus decies et ultra longioribus." *Ehr. l. c. p.* 18.

I now feel confident that these two supposed species are only different positions of the same species. I have seen as many as 15 to 20 individuals in the Bermuda Tripoli, and have sometimes succeeded, by means of Chevalier's compresser, in turning them over so as to observe the two sides of the same individual, and have thus ascertained that these two sides differ in outline, as shown in figs. 18 and 19, and I would therefore retain for the species the name *C. Diploneis.*

3. "*Denticella? polymera.* (Fig. 20.)—Testulæ latissimæ brevisque septis lobisque lateralibus in adultu 10 (–12), granulis in lobi medii facie anteriore 6 majoribus stellam formantibus (denticulis setaceis lateralibus extra medium positis) aperturarum tubulis longe exsertis. Latit. $\frac{1}{11}'''$. Bermuda.

"Fragmentum vidi setis expers, hinc Biddulphiæ generi hanc formam adscripsissem, sed Prof. Bailey in icone missa unius lateris setam delineavit. *Denticellæ tridentatæ* statum eximie adultum hanc formam referre non censeo quoniam lobi novæ majorisque formæ depressiores sunt. Lobos 10 ipse observavi 12 Bailey delineavit." *Ehr. l. c. p.* 19.

This form appears to be rather rare; a copy of the outline which I sent to Ehrenberg is given in fig. 20.

4. "*Dictyocha Ponticulus.* (Fig. 21.)—Lanceolata oblonga, arcu medio transverso simplici in duas cellulas divisa margine inermi. Diam. $\frac{1}{36}'''$. Bermuda.

5. "*Dictyocha Quadratum.* (Fig. 22.)—Quadrata aut subquadrata oblonga, arcu medio transverso simplici in duas cellulas divisa spina in utroque latere angustiore medio singula. Diam. $\frac{1}{40}'''$. Bermuda.

"Has duas formas Prof. Bailey primus observavit et delineatus misit. Multa specimina ipse vidi." *Ehr. l. c. p.* 19–20.

These well characterized species are very abundant in the Bermuda Tripoli, but have not been detected at any other locality.

6. "*Triceratium Solenoceros.* (Fig. 23.)—Testulæ lateribus profunde concavis, apicibus longe tubulosis radiatis subacutis superficie granulorum seriebus radiantibus rectis ornata, granulis in $\frac{1}{100}$ lineæ 15. Diam. $\frac{1}{23}'''$. Bermuda.

"Prof. Bailey hujus iconem circumscriptam misit. Nonnulla specimina ipse inveni." *Ehr. l. c. p.* 26.

This remarkable species is easily recognized by the excessively elongated angular processes.

7. "*Zygoceros? Bipons.* (Fig. 24.)—Testula a latere lanceolata utroque apice acuto et corniculo admodum parvo instructo, stricturis mediis lævibus duabus, superficie subtiliter granulata nec radiata. Diam. $\frac{1}{32}'''$. Bermuda." *Ehr. l. c. p.* 26.

The true nature of this form is unknown. It is quite common in the Bermuda earth.

For an account of many other interesting forms from Bermuda, I must refer to Ehrenberg's own memoir. A list of all the species noticed by Ehrenberg is given in the table on pages 331–335, by which it will be seen that this remarkable infusorial deposit agrees with those of Virginia and Maryland in containing many species, such as *Eupodiscus Rogersii*, *Goniothecium Odontella*, various species of *Rhizosolenia*, *Dicladia*, &c. which have hitherto been considered as exclusively American forms. It is also remarkable that the Bermuda specimen, like all those from Virginia, contains no trace of calcareous Polythalamia, although I have found these to be very abundant in specimens of recent sands and limestones of the Bermuda Islands.

The occurrence of this remarkable infusorial formation at Bermuda is of much interest, as it shows that such formations are not confined to the harbors and estuaries of a continent, but may also occur on the "still vexed" shores of the lone isles of the ocean.

It is also remarkable that a deposit so purely siliceous could be formed among the coralline isles of Bermuda. No mention of any such "Tripoli" is contained in any of the accounts of the geology of those islands which I have yet seen. It is therefore

very desirable that any one possessed of facts connected with so interesting a locality should publish them as soon as possible.

III. *Fossil Infusoria of Virginia and Maryland.*—I have recently been furnished by Prof. W. B. Rogers with interesting specimens of fossil infusoria from several new localities discovered by himself in Virginia, viz. at Rappahannock Cliffs, Stratford Cliffs, Brown's Mills, Westmoreland Court House, and Meherrin River. I am also indebted to Mr. Tuomey for a large collection of infusorial specimens from the localities discovered by himself in the neighborhood of Petersburg; and specimens from Hollis Cliffs, Va. have been given to me by Mr. Tuomey, by Prof. Rogers, and by Francis Markoe, Esq., but I have not been informed who was the discoverer of this locality.

In order to show in a connected manner the results of the examinations hitherto made upon the infusorial remains in the tertiary of Virginia and Maryland, I present the following table, which also includes a list of the species found by Ehrenberg in the Tripoli of Bermuda. The first four columns are on the authority of Ehrenberg; the others are the results of my own observations, and are very far from being complete, as many of Ehrenberg's species are still unknown to me. I have carefully refrained from including in the lists any form of whose true name I felt any doubt. As specimens from all these localities have been sent by me to Ehrenberg, we may shortly be able on his authority to give much more complete lists.

In this table a (*) placed opposite to a species, shows that it occurs at the locality whose name is placed above the star. If a (†) is placed to the left of a specific name, it indicates that the species is, according to Ehrenberg, known in the recent as well as in the fossil state. Where I have observed a species which is omitted by Ehrenberg in his lists for the first four localities, I have added a B to the star.

Where the name of the discoverer of a locality is known to me, I have added it to the name of the place.

TABLE *showing the species of Infusoria, Phytolitharia, &c. found Fossil at Bermuda, and at various localities in the Tertiary of Virginia and Maryland.*

	Bermuda: specimens received from M. Tuomey, Esq.	Richmond, Va.: discovered by Prof. W. B. Rogers.	Petersburg, Va.: discovered by M. Tuomey, Esq.	Piscataway, Md.: discovered by Prof. W. B. Rogers.	Rappahannock Cliffs, Va.: discovered by Prof. W. B. Rogers.	Stratford Cliffs: discovered by Prof. W. B. Rogers.	Brown's Mills, Westmoreland C. H.: discovered by Prof. W. B. Rogers.	Hollis Cliffs, Va.: discovered by ——?	Meherrin River, Va.: discovered by Prof. W. B. Rogers.	Fossil species which have also been found in a recent state on the coast of U. States by Prof. J. W. Bailey.
Actiniscus †Pentasterias,	*	*		*		*	*	*		*
†Sirius,		*								
Tetrasterias,		*								
Actinocyclus †quinarius,	*	*		*					*	
†biternarius,	*			*					*	
†septenarius,	*	*	*	*					*	
†octonarius,	*	*		*		*				
†nonarius,	*	*	*	*						
†denarius,	*	*	*	*				*		
†undenarius,	*	*	*	*		*	*			
†bisenarius,	*	*	*	*		*				*
†tredenarius,	*	*	*	*		*	*			
biseptenarius,	*	*	*	*			*			
†quindenarius,	*	*		*		*	*			
†bioctonarius,	*	*								
septemdenarius,	*						*			
binonarius,	*									*
novemdenarius,	*									
vicenarius,	*									
Luna,	*									
Ceres,	*				*			*	*	
Juno,	*									
Jupiter,	*									
Mars,	*									
Mercurius,	*									
Pallas,	*									
Saturnus,	*									
Terra,	*									
Venus,	*									
Uranus,	*									
Aquila,	*									
Bet-el-gose,	*									
Canopus,	*									
Actinoptychus quaternarius,		*	*							
†senarius,	*	*	*	*	*	*	*	*	*	*
biternarius,	*	*	*	*						
velatus,	*		*	*						
†octonarius,		*	*	*		*			*	
nonarius,			*	*						
†denarius,		*	*	*			*		*	
†duodenarius,		*	*			*			*	*
†quatuordenarius,		*	*						*	
†sedenarius,		*	*							
†octodenarius,		*	*							
vicenarius,		*							*	
Ceres,		*								
Jupiter,		*						*	*	

TABLE CONTINUED.

	Bermuda: specimens received from M. Tuomey, Esq.	Richmond, Va.: discovered by Prof. W. B. Rogers.	Petersburg, Va.: discovered by M. Tuomey, Esq.	Piscataway, Md.: discovered by Prof. W. B. Rogers.	Rappahannock Cliffs, Va.: discovered by Prof. W. B. Rogers.	Stratford Cliffs: discovered by Prof. W. B. Rogers.	Brown's Mills, Westmoreland C. H.: discovered by Prof. W. B. Rogers.	Hollis Cliffs, Va.: discovered by ——?	Meherrin River, Va.: discovered by Prof. W. B. Rogers.	Fossil species which have also been found in a recent state on the coast of U. States by Prof. J. W. Bailey.
Anaulus? Campylodiscus,	*									
Asterolampra Marylandica,				*						
Aulacodiscus Crux,	*	*	*							
Biddulphia tridentata,	*	*	*	*						
?lunata,		*								
Gigas,	*									
Campylodiscus Clypeus,	*									
Chætoceros Diploneis,	*									
Chætotyphla Pyritæ?			*							
Coscinodiscus asteromphalus,		*								
apiculatus,		*			*	*	*			*
†centralis,		*								
concavus,		*								
†disciger,			*							
†excentricus,	*	*	*							*
gemmifer,	*									
Gigas,		*		*						
heteroporus,	*									
†lineatus,		*	*	*	*					*
†marginatus,		*	*	*	*	*	*			*
†minor,		*								
Oculus-Iridis,		*	*	*		*	*	*	*	*
Omphalanthus,	*									
perforatus,	*	*		*B						
†radiolatus,	*	*	*	*	*	*				*
†subtilis,	*	*	*							
velatus,		*								
Craspedodiscus elegans,	*									
Coscinodiscus,		*	*		*	*		*		
Denticella polymera,	*									
Rhombus,			*			*	*	*	*	
tridentata,	*		*	*		*	*	*	*	
tumida,	*									
Dicladia Capreolus,		*	*							
clathrata,	*									
Dictyocha †aculeata,			*							*
†Crux,	*	*	*	*						
Epiodon,		*		*						
†Fibula, α	*	*		*	*	*	*	*	*	*
Fibula, β				*	*	*	*	*	*	*
hemisphærica,	*									
Ponticulus,	*									
Quadratum,	*									
†Speculum,		*			*				*	*
Staurodon,		*								
†triactis (triacantha),	*			*		*	*	*		
ubera,				*						
Discoplea Actinocyclus,	*									
Americana,			*	*B	*	*			*	

TABLE CONTINUED.

	Bermuda: specimens received from M. Tuomey, Esq.	Richmond, Va.: discovered by Prof. W. B. Rogers.	Petersburg, Va.: discovered by M. Tuomey, Esq.	Piscataway, Md.: discovered by Prof. W. B. Rogers.	Rappahannock Cliffs, Va.: discovered by Prof. W. B. Rogers.	Stratford Cliffs: discovered by Prof. W. B. Rogers.	Brown's Mills, Westmoreland C. H.: discovered by Prof. W. B. Rogers.	Hollis Cliffs, Va.: discovered by ——?	Meherrin River, Va.: discovered by Prof. W. B. Rogers.	Fossil species which have also been found in a recent state on the coast of U. States by Prof. J. W. Bailey.
Discoplea denticulata,	*									
undata,	*									
Eunotia †Diodon,		*								
†Monodon?		*								
†gibba,		*								
Eupodiscus †Germanicus,	*	*	*	*	*					*
quaternarius,	*									*
quinarius,	*									
†Rogersii,	*B		*	*B	*	*	*	*	*	*
†Baileyi,			*							
Flustrella concentrica,	*			*						
Fragillaria amphiceros,		*								
lævis,		*								
leptoceros,		*								
†pinnata,		*								
Gallionella †sulcata,	*	*	*	*	*	*	*	*	*	*
Gomphonema †clavatum,		*								
†minutissimum,		*								
Goniothecium didymum,		*								
Gastridium,		*								
hispidum,			*							
Monodon,	*		*	*						
Navicula,	*	*								
obtusum,		*								
Odontella,	*	*	*	*	*			*		
Rogersii,	*	*								
Grammatophora †Africana,		*	?							
†angulosa,		*								
†oceanica,		*	*B							*
†parallela,		*								
†stricta,	*									*
†undulata,		*								
Haliomma Amphisiphon,	*									
Æquorea?		*		*						
crenatum,		*								
nobile,	*									
Heliopelta Leeuwenhoekii,	*									
Metii,	*									
Euleri,	*									
Selligueii,	*									
Hercotheca mammilaris,	*									
Lithobotrys quadriloba,			*	*						
Lithocampe aculeata,	*									
antartica,	*									
Radicula?				*	*	*		*		
solitaria,				*						
Mastogonia Actinoptychus,	*	*	*	*	*					
Crux,	*									
heptagona,	*									

TABLE CONTINUED.

	Bermuda: specimens received from M. Tuomey, Esq.	Richmond, Va.: discovered by Prof. W. B. Rogers.	Petersburg, Va.: discovered by M. Tuomey, Esq.	Piscataway, Md.: discovered by Prof. W. B. Rogers.	Rappahannock Cliffs, Va.: discovered by Prof. W. B. Rogers.	Stratford Cliffs: discovered by Prof. W. B. Rogers.	Brown's Mills, Westmoreland C. H.: discovered by Prof. W. B. Rogers.	Hollis Cliffs, Va.: discovered by ——?	Meherrin River, Va.: discovered by Prof. W. B. Rogers.	Fossil species which have also been found in a recent state on the coast of U. States by Prof. J. W. Bailey.
Mastogonia Oculus-Chamæleontis,	*			*	*					
quinaria,	*									
Rota,	*				*		*			
sexangula,	*									
Mesocena Diodon,				*						
elliptica,	*			*						
triangula,	*			*	*					
Navicula omphalia,	*									
†Sigma,		*			*				*	*
Omphalopelta areolata,	*					*				
cellulosa,	*				*		*			
punctata,	*									
versicolor,	*									
Periptera Capra,		*								
Cervus,				*			*			
Chlamidophora,	*									
Tetracladia,	*									
Pinnularia Entomon,	*									
(*Diploneis*) †didyma,	*	*	*	*	*		*	*		*
diomphala,		*	*							
(*Mononeis*) †peregrina,		*	*		*	*	*	*	*	*
†viridis,		*								
Pyxidicula areolata,			*							
apiculata [Systephania? B.]			*							
(*Dictyopyxis*) cruciata,	*		*	*	*	*	*	*	*	
" Cylindrus,				*						
" hellenica,	*			*						
" Lens,		*								
" (? B.) Actinocyclus,		*								
" Gemmifera,				*	*	*	*	*		
" cristata,		*								
" limbata,				*						
(*Stephanopyxis*) aculeata,	*	*	*	*		*	*			
(*Xanthiopyxis*) alata,	*									
" constricta,	*	*								
" (? B.) hirsuta,				*	*					
" globosa,	*									
" oblonga,	*				*					
Rhaphoneis †Amphiceros,		*	*	*						
Fusus,	*		*							
gemmifera,				*	*					
Leptoceros,		*	*							
pretiosa,				*						
†Rhombus,		*	*		*		*	*		*
scalaris,	*									
Rhizosolenia Americana,		*	*	*	*	*		*		
?barbata,	*									
Calyptra,	*									
Campana,	*									

TABLE CONTINUED.

	Bermuda: specimens received from M. Tuomey, Esq.	Richmond, Va.: discovered by Prof. W. B. Rogers.	Petersburg, Va.: discovered by M. Tuomey, Esq.	Piscataway, Md.: discovered by Prof. W. B. Rogers.	Rappahannock Cliffs, Va.: discovered by Prof. W. B. Rogers.	Stratford Cliffs; discovered by Prof. W. B. Rogers.	Brown's Mills, Westmoreland C. H.: discovered by Prof. W. B. Rogers.	Hollis Cliffs, Va.: discovered by ——?	Meherrin River, Va.: discovered by Prof. W. B. Rogers.	Fossil species which have also been found in a recent state on the coast of U. States by Prof. J. W. Bailey.
Rhizosolenia Pileolus,		*	*							
Ornithoglossa,	*									
Sceptroneis Caduceus,	*									
Stauroneis Sigma,		*								
Stephanogonia quadrangula,	*									
polygona,	*									
Symbolophora Trinitatis,				*						
Synedra Linea,		*								
Ulna,		*								
?incurva,	*									
Systephania aculeata,	*									
Corona,	*									
Diadema,	*									
Tetrachæta ——? (Triceratium spinosum, B.)			*							
Triceratium amblyoceros,	*	*		*B	*		*	*		
acutum,	*									
condecorum,	*									
obtusum,	*	*	*		*					
Pileus,			*							
†Reticulum,	*	*	*	*	*		*	*	*	*
Solenoceros,	*									
undulatum,	*									
Zygoceros †Rhombus,			*							*
Bipons,	*				*					
stiliger,	*									
PHYTOLITHARIA.										
Amphidiscus †clavatus,			*							
Lithasteriscus †radiatus,		*		*						
†reniformis,				*						
tuberculosus,	*	*		*	*	*	*			*
†amphiodon,			*							
Lithodontium furcatum,	*									
†Clepsammidium,		*	*							
Amphidon,	*									
Serra,	*									
Spongiolites †acicularis,		*		*					*	*
appendiculata,		*								
†aspera,		*								*
Caput-Serpentis,	*	*								
†cenocephala,	*	*			*	*	*		*	*
†Clavus,		*	*	*			*	*		
collaris,		*		*						
†foraminosa,	*	*			*	*				
†Fustis,		*	*	*	*					*
uncinata,				*					*	
unguiculata,		*								

Among the forms which occur at some of the localities above mentioned, and which I have not been able to identify with any of those described by Ehrenberg, are the following:

1. *Biddulphia* ——, *n. sp.?* (Fig. 24, 24*a.*)—This is somewhat allied in form to *Denticella tridentata*, but I have never seen any lateral setæ upon it. It may be recognized by the curves at the base of the lines of constriction of the lorica. It occurs sparingly at Rappahannock Cliffs, and is more abundant at Brown's Mills, Va.

2. *Triceratium* ——, *n. sp.?* (Fig. 25.)—This species has each of its angles subtended by an arc of the circle, so as to form with the sides a somewhat hexagonal figure in the middle of the triangular faces. It occurs fossil at Meherrin River, and recent at Charleston, S. C.

3. *Goniothecium?* ——. (Fig. 26.)—These forms consist of elliptical shield-shaped plates, with a large elevated umbone surrounded by a narrow margin. They occur at Bermuda, Rappahannock Cliffs, Brown's Mills, &c.

4. *Lithocampe* ——. (Fig. 27.)—This remarkably perfect specimen of Lithocampe was found by me in the infusorial earth from Piscataway, Md.

There are also several species of Rhaphoneis occurring at most of the localities, which I cannot determine positively; one of the most remarkable occurs abundantly at Rappahannock Cliffs, and has very elongated rounded terminations, greatly resembling the upper end of *Sceptroneis Caduceus*, (fig. 11.)

A species of Stauroptera from the locality at Meherrin River is shown in fig. 28. It has not been found fossil at any other locality.

The following are offered as some of the general conclusions drawn from the observations above recorded.

1. The species at all the above mentioned localities are exclusively marine.

2. The different localities have many species in common, the number of which will doubtless be increased by further observation.

3. The species which appear to have been most extensively diffused in the seas from which the fossil deposits were made, are the very species which in the recent state appear to be cosmopolites; as for example, *Actiniscus Pentasterias*, *Actinoptychus senarius*, *Coscinodiscus apiculatus*, *C. marginatus*, *C. lineatus*,

Dictyocha Fibula, Gallionella sulcata, Rhaphoneis Rhombus, Triceratium Reticulum, &c.

4. There are a great number of *fossil* species at these localities, which, although very easy to be recognized, have *never* been found in a *recent* state, and are therefore probably *extinct.*

5. On the other hand there are numerous well characterized *recent* species which are every where present in the deposits of our present seas, which have *never* been found in the *fossil* state, although they are so large and well marked that it would be impossible to overlook them if they were present. Among these may be mentioned *Biddulphia pulchella, Isthmia obliquata, Triceratium favus, Gallionella moniliformis, Tessella catena, Achnanthes brevipes, Cocconeis oceanica*, &c. These are therefore probably of recent creation.

6. It hence appears that the same successive extinction of some species and creation of others, which has taken place with regard to the larger tribes of organic beings, has also occurred with the most minute races.

7. The specimens from all the above localities agree in the total absence of the calcareous-shelled Polythalamia, although these calcareous forms are very abundant in the associated beds in which the shells of mollusks are found in an undecomposed state.

IV. *Recent Infusoria in the Blue Mud of New Haven Harbor.*—This mud, which is used I believe as a fertilizer, was recently analyzed by B. Silliman, Jr. and the following results obtained.

Silica,	58·633
Alumina,	30·563
Oxide of iron,	6·186
Carbonate of lime,	4·263
Magnesia,	0·705
	100·348

Some of the same mud was given me by Mr. Silliman, with the request to examine it by the microscope. The contents which I found were as follows—viz. particles of quartz, hornblende, and feldspar, mingled with great numbers of siliceous infusoria, among which were noticed *Actinocyclus senarius, Coscinodiscus excentricus, C. oculus-iridis, Cocconeis oceanica, Dictyocha speculum, D. Fibula, Dicladia* —— ? *Eunotia Westermanni, Gallionella sulcata, Grammatophora oceanica, Pinnu-*

laria peregrina, *P. lyra*, *P. didyma*, *Rhaphoneis Rhombus*, *Tessella catena*, *Spongiolites caput-serpentis*, and a few calcareous Polythalamia. The most interesting form is what appears to be a new species of Dicladia, a genus which has heretofore only been seen in the fossil state. A figure of the species found at New Haven is given in fig. 29.

V. *Recent Infusoria in Mud from Charleston Harbor, S. C.*—A portion of the mud taken from the logs of a wharf in Charleston, S. C. was given to me for examination by Mr. Tuomey. It proved to be quite rich in siliceous infusoria, and also contained a large number of recent calcareous Polythalamia. The following is a list of the contents, as far as I have been able to identify them—viz. *Actinocyclus senarius*, *A. bisenarius*, *Biddulphia pulchella*, *Coscinodiscus excentricus*, *C. patina*, *C. lineatus*, *Dictyocha fibula* α *et* β, *Eupodiscus Germanicus*, *E. Rogersii*, *Fragillaria* —— ? *Navicula Baltica*, *N. Sigma*, *Pinnularia didyma*, *Rhaphoneis Amphiceros?* *R. Rhombus*, *Stauroptera aspera*, *Triceratium favus* in very large and beautiful specimens, *Triceceratium Reticulum*, *Zygoceros Rhombus*, *Zygoceros Emersonii*, B., *Lithasteriscus tuberculosus*, *Spongiolites acicularis*, *S. cenocephala*, spines of an Echinoderm (Scutella?) and numerous minute but perfect rhombohedral crystals, probably of calc spar.

VI. *Fossil Infusoria in Guano.*—Believing that guano would be likely to contain siliceous infusoria which had been swallowed by sea fowl, and which would not be acted upon in the alimentary canal, I was led to submit to microscopic examination a portion of South American guano, which was furnished to me by Dr. Torrey as an unadulterated specimen. By first removing the soluble and volatile portions, and then diffusing the residue in Canada balsam, I readily found well characterized specimens of Coscinodiscus, Actinocyclus, and other marine infusoria. The species appear to be such as are now living in the waters of the Atlantic, but it is possible that novel and interesting forms may be yet detected, and perhaps some information may by this means be derived as to the relative age of the different deposits.*

* Since the above observations were made by me, I have received a letter from Robert Harrison, Esq. of Hull, England, dated Nov. 3d, 1844, from which it appears that he also has sought for and found infusoria in guano. He remarks: "I have also found some interesting infusorial forms in the guano of Ichaboe; if you have not seen them, you will be pleased with them."

VII. *Fossil Infusoria of Nova Scotia.*—Specimens of fossil fluviatile infusoria have been sent to me for examination from two localities in Nova Scotia. The first was sent by J. W. Dawson, Esq. from Earlton, Colchester County, Nova Scotia; and the second was received from Owen Mason, Esq. of Providence, R. I., but the precise locality in Nova Scotia from which the latter was obtained, was not mentioned. Both these specimens present all the characters of the purely siliceous infusorial deposits so common in our peat bogs. They are both very white, light, and free from sand. The species most abundant in the specimen from Earlton, are *Pinnularia viridis*, *Cocconema cymbiforme*, *Gomphonema acuminatum*, *Eunotia Monodon*, *E. Pentodon*, *E. serra*, *Gallionella distans*, *Himantidium arcus*, *Surirella splendida*, *Stauroneis Baileyi*, *Spongiolites lacustris*, *S. erinaceus*, &c.

In the specimen sent by Mr. Mason, the chief forms noticed by me were the following: *Pinnularia viridis*, *P. inæqualis*, *Cocconema cymbiforme*, *Gallionella distans* very abundant, *Himantidium arcus*, *Tabellaria trinodis*, *Eunotia Monodon*, *E. Diodon*, *Synedra valens*, &c. No Spongiolites were seen. This specimen is remarkably pure, and free from any mixture of sand or organic coloring matters.

VIII. *Fossil Infusoria with the Bones of the Mastodon.*—I have been furnished by Mr. Connors with specimens of the marl and clay in which was imbedded the admirably preserved head of the *Mastodon giganteus*, discovered in 1843, in Scotchtown, Orange County, New York. The clay and marl were collected at the time the bones were exhumed, and I was assured by Mr. Connors that the marl of which he gave me specimens was a portion collected by himself, of that in which the bones were *imbedded.* This marl is of a light ash-gray color, and contains numerous well preserved fresh-water shells of recent species, among which were several common species of Planorbis, Cyclas, and Lymnæa, some of which still retained their epidermis.

In order to ascertain if this marl contained any siliceous infusoria, I treated it with diluted hydrochloric acid to dissolve out all calcareous matter, and to concentrate in a small mass such insoluble bodies as might be present. The insoluble portion thus obtained was then washed, diffused on glass in Canada balsam, and examined by the microscope. Among the bodies detected,

were *Pinnularia inæqualis*, *Cocconema cymbiforme*, *Gallionella distans*, *Himantidium Arcus*, *Stauroneis Baileyi*, *Surirella splendida*, *Spongiolites lacustris*, *Closterium crenulatum!* *stellate hairs of Platanus?* *pollen of Pine*, and *seed-vessels of Nitella* or *Chara*.

If, as I have no reason to doubt, the marl examined was really that in which the bones were imbedded, these results are interesting as they prove, 1st. That siliceous infusoria identical with those now living were cotemporaneous with the mastodon. 2d. That not only siliceous but *membranaceous* infusoria, hairs of plants, &c. may be preserved for ages in calcareous marls, where they may be detected after the calcareous matter is dissolved by acids.

In connection with this I may state, that this same method of observation was applied by me two years ago to specimens of calcareous marls from New Hampshire, sent by Prof. Hubbard, and marls from New York, sent by Prof. James Hall, and that I detected in them not only siliceous infusoria, but a number of well preserved membranaceous coverings of animalcules, such as various species of Closterium, Euastrum, &c. I believe that the occurrence of these in a fossil state has not previously been noticed.

IX. *Fossil Polythalamia of the United States.*—I take this opportunity to tender my thanks to numerous persons who have kindly sent me specimens of various secondary and tertiary marls; and although I have myself, from the want of time and *books*, shrunk from the task of determining and describing the numerous species of American fossil Polythalamia which I have thus been enabled to prove to exist at so many localities; yet no one can regret this, as I have been fortunate enough to induce Ehrenberg to undertake this labor. I have lately had the pleasure of learning from him that he has received all the specimens which I have forwarded to him, and that he is actively engaged in studying them. While we wait therefore for the results of Ehrenberg's examination, it may still be of some interest to present a list of all the North American localities at which I have proved Polythalamia to exist. They are enumerated in the following table.

	Nature of Specimen.	*Locality.*	*From whom received.*
1.	Carboniferous limestone,	——, Illinois,	D. D. Owen.
2.	Yellowish gray calcareous sandstone = 3d formation of upper secondary of Prof. Rogers's Report on New Jersey,	Mullica Hill, New Jersey,	Lt. French, U. S. A.
		Timber Creek, "	Mrs. Allen, Gardiner, Me.
		Near Mt. Holly, "	J. W. Bailey.
3.	Green Sand in a Belemnite,	New Jersey,	J. W. Bailey.
4.	Nummulite limestone and other specimens,	Claiborne Bluff, Alabama,	Dr. John Torrey.
5.	"Rotten limestone,"	Prairie Bluff, "	Lt. G. W. Rains, U. S. A.
6.	Marl and limestone,	Selma, "	" " " "
7.	Yellow and gray calcareous marl,	Cretaceous formations on Missouri River,	J. N. Nicollet.
8.	Gray calcareous marl,	Mission station, northern part of the State of Mississippi,	B. Silliman, Jr.
9.	Marl, with *Exogyra costata*,	Cretaceous formation, S. C.	M. Tuomey, Esq.
10.	Borings of Artesian well,	Columbus, Mississippi,	B. Silliman, Jr.
11.	Cretaceous marl,	Mc Naer's County, Tenn.	D. D. Owen.
	" "	White Cliffs, Arkansas.	
12.	Borings of Artesian well,	Charleston, South Carolina,	Dr. J. Lawrence Smith.
13.	Tertiary marl,	Oregon Territory,	J. D. Dana, Esq.
14.	Eocene marl,	Pamunkey River, Virginia,	Mr. Tuomey.
	" "	Fort Washington, "	Prof. W. B. Rogers.
15.	Matrix of bones of Zygodon,	——, Alabama,	Mr. Buckley.
16.	Meiocene marl,	Petersburg, Virginia,	Mr. Tuomey.
17.	" "	Pamunkey River, "	" "
18.	" "	Wilmington, North Carolina,	J. D. Hodge.
19.	" "	North Carolina,	Mr. Tuomey.
20.	Post pleiocene,	South Carolina,	" "

Without anticipating the results of Ehrenberg's examination of the above materials, I may be allowed to state, as the result of my own observations,

1st. That all these specimens abound in Polythalamia, and that they are remarkably abundant and beautifully preserved in the specimens from Charleston, S. C., Petersburg, Va., Pamunkey River, Va., and in Mr. Nicollet's specimens from the Missouri River.

2d. The specimens from Fort Washington presented me with what I believe have never before been noticed, viz. distinct *casts* of Polythalamia. That these minute and perishable shells should, when destroyed by chemical changes, ever leave behind them indestructible memorials of their existence, was scarcely to be expected, yet these casts of Polythalamia are abundant and easily to be recognized in some of the eocene marls from Fort Washington. A figure of one of these casts is given in fig. 30.

3d. The *groups* of Polythalamian forms in the different geological formations of North America are remarkably distinct, and when they have been properly studied and the *characteristic*

forms of each determined, it will be easy to ascertain the true position of any secondary or tertiary deposit from the examination of geological specimens not larger than mustard seed, and which to the naked eye would offer no trace of organic remains.

4th. Microscopic bivalve crustaceans, resembling Cypris in form but of marine origin, are very abundant in many of our tertiary deposits.

EXPLANATION OF THE FIGURES IN THE PLATE.

All the sketches which accompany this paper, except A, B, C, and D, were drawn from nature by myself, by means of the camera lucida eye-piece attached to Chevalier's microscope. Most of them are mere outlines; but it is believed they will assist a student of this difficult subject. They are all drawn to the scale shown in fig. 32. Figs. A, B, C, and D, are copied from a plate of Ehrenberg's in the Report of the Berlin Academy for June, 1844.

Fig. A. Heliopelta Leeuwenhoekii, Ehr. Fossil at Bermuda.

Fig. B. Asterolampra Marylandica, Ehr. Fossil at Piscataway, Md.

Fig. C. Symbolophora Trinitatis, Ehr. Fossil at Piscataway, Md.

Fig. D. Craspedodiscus elegans, Ehr. Fossil at Bermuda.

Figs. 1, 2, 3, 4. End views of fossil infusoria allied to Terpsinoe? Oregon.

Fig. 5. Side view of the same. Oregon.

Fig. 6. New species of Surirella. Fossil at Oregon.

Fig. 7. New species, α of Gallionella. Fossil at Oregon.

Fig. 8. New species, β of Gallionella. Fossil at Oregon.

Fig. 9. New species, γ of Gallionella. Fossil at Oregon.

Fig. 10. Small fossil Navicula? Fossil at Oregon.

Fig. 11. Sceptroneis Caduceus, Ehr. Fossil at Bermuda.

Fig. 12. Mastogonia heptagonæ? Ehr. Fossil at Bermuda.

Fig. 13. Stephanogonia polygona, Ehr. Fossil at Bermuda.

Fig. 14. Xanthiopyxis oblonga, Ehr. Fossil at Bermuda.

Figs. 15, 16, 17. Peripteræ? Fossil at Bermuda.

Fig. 18. Chætoceros Bacillaria, Ehr. Fossil at Bermuda.

Fig. 19. Chætoceros Diploneis, Ehr., with the spines partly broken off. Fossil at Bermuda.

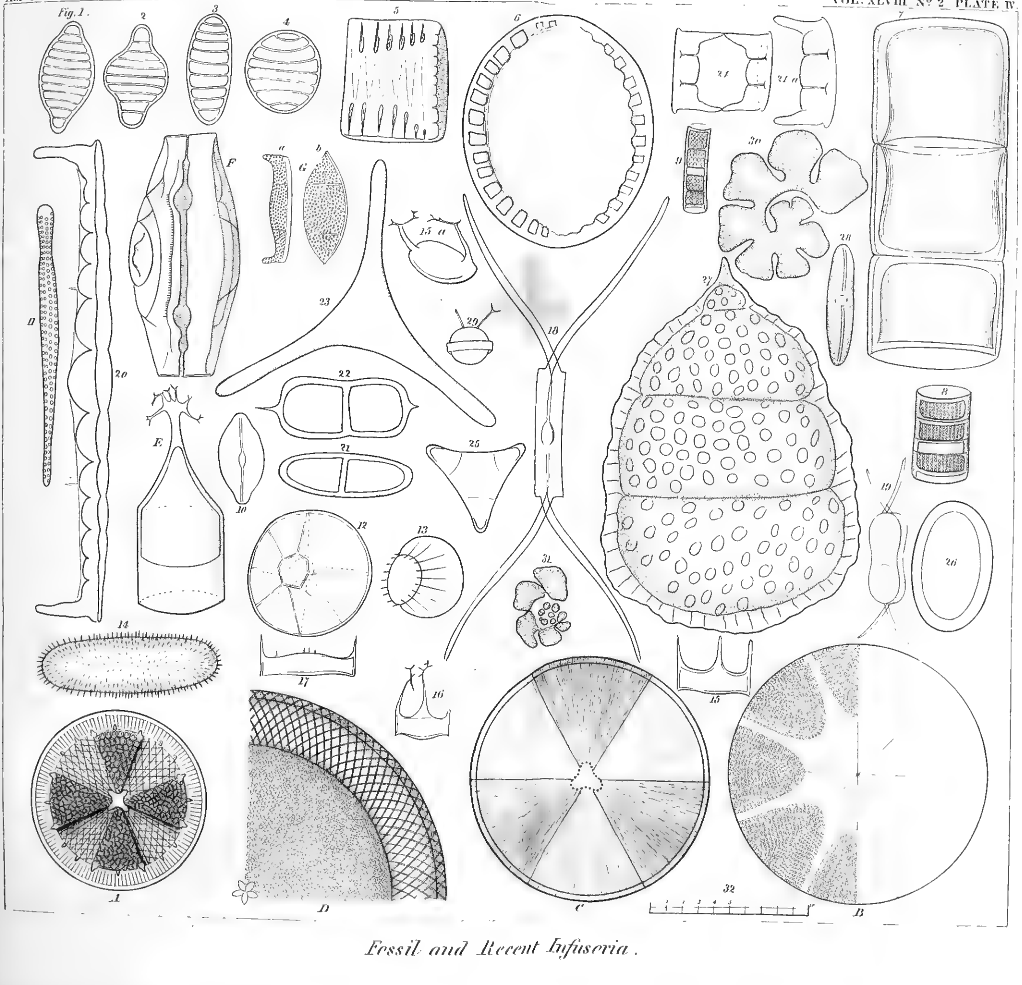
These figures, 18 and 19, I believe are only different *positions* of the *same* species, for which I would retain the name *C. Diploneis*, Ehr.

Fig. 20. Denticella polymera, Ehr. Fossil at Bermuda.

Fig. 21. Dictyocha Ponticulus, Ehr. Fossil at Bermuda.

Fig. 22. Dictyocha Quadratum, Ehr. Fossil at Bermuda.

Fig. 23. Triceratium Solenoceros, Ehr. Fossil at Bermuda.



Fossil and Recent Infusoria.

Fig. E. Rhizosolenia ! ——— ? Fossil at Bermuda.

Fig. F. Goniothecium Odontella, Ehr. Fossil at Bermuda and Virginia.

Fig. G. Zygoceros ? Bipons, Ehr. Fossil at Bermuda.

Figs. 24 and 24*a*. Biddulphia or Denticella, new species. Fossil at Brown's Mills, near Westmoreland Court House, Va.

Fig. 25. Triceratium ———, new species ? Fossil at Meherrin River, recent in Charleston harbor.

Fig. 26. Goniothecium ? ———, new genus ? Fossil at Bermuda, Rappahannock Cliffs, Brown's Mills, &c.

Fig. 27. Lithocampe ———, new species ? Fossil at Piscataway, Md.

Fig. 28. Stauroptera ———, new species ? Fossil at Meherrin River, Va.

Fig. 29. Dicladia ———, new species ? Recent in New Haven harbor, Conn.

Fig. 30. Cast of a fossil Polythalamian shell. Petersburg, Va.

Fig. 31. Cast of a fossil Polythalamian shell. Fort Washington, Va.

Fig. 32. Scale showing $\frac{10}{100}$ths of a millimetre, magnified equally with the drawings.

Art. XII.—*Description of Fossil Footmarks, found in the Carboniferous Series in Westmoreland County, Pennsylvania;* by Alfred T. King, M. D.

Remarks.—After this article was in type, the Proceedings of the Academy of Natural Sciences of Philadelphia, for November and December, 1844, reached us with the same account of these footmarks from Dr. King, which he had sent for this Journal, except a substitution of the generic name *Thenaropus* for some of the tracks included. A later communication from Dr. King, accompanying a drawing of the slab, figured in parts, on pp. 350, 351, desires us to change again the name Thenaropus—which we have accordingly done, taking the liberty however of abbreviating his proposed name *Spheropezopus* to Spheropezium. Dr. K. desires that the name Thenaropus (*T. heterodactylus*) may be given to the supposed Batrachian tracks. Yet we would suggest the propriety of his adopting some new name, as a new use of this word will only create increased confusion. We have ventured also to make some condensation of the original matter, which is published in full in the Proceedings referred to.—Eds.

The footmarks here described are the first decided indications, so far as my information extends, of the existence of birds or other highly organized animals, as early as the carboniferous period.*

The tracks are referable to at least seven species, and have the following characters.

Ornithichnites† *gallinuloides*, (fig. 1.) The tracks appear to belong to the order Gralla, and may be allied to our *gallinules*.

Fig. 1.

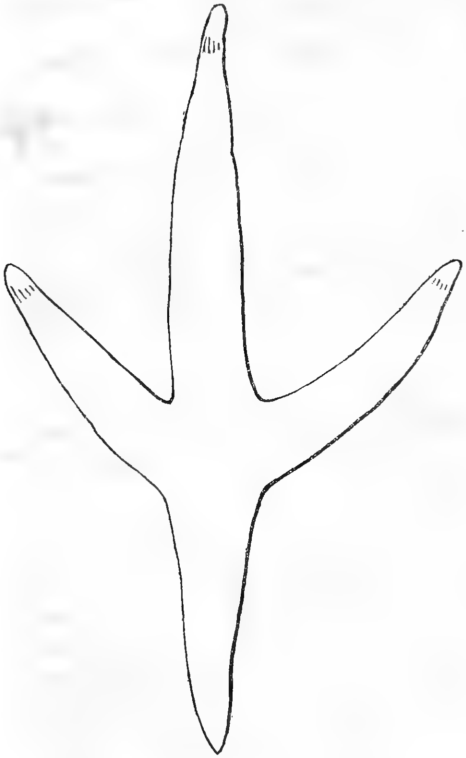


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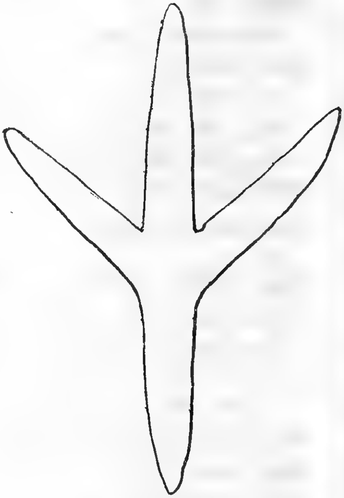
Fig. 2.



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Toes 4, three before, leptodactylous, pointing forwards, almost entirely separate; middle toe much the longest; spread of the lateral toes 90°; hind toe pointing directly backwards, (on one foot there was a slight inclination inwards,) on the same level

* Dr. King was not aware when this was written, that Mr. Logan had discovered tracks on the carboniferous rocks of Nova Scotia, which have been referred by Mr. Owen to unknown Reptilia. (See this Journal, Vol. XLV, p. 358.)—*Eds.*

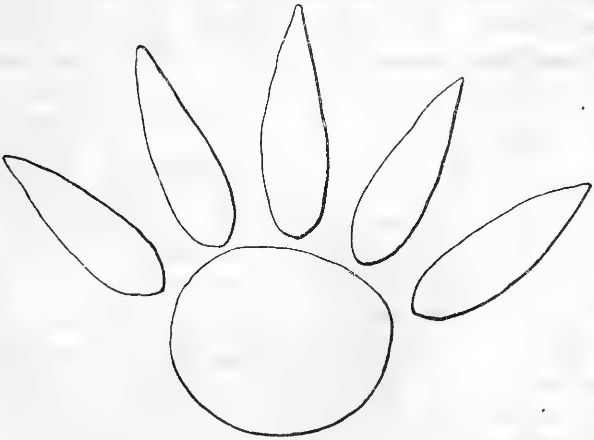
† This term, proposed originally by Prof. Hitchcock, is preferred to his more recent *Ornithoidichnites*.

with the front ones; all the toes have long and pointed claws; length of the foot 9 inches; length of the step varied from 2 to 15 or 18 inches.

Ornithichnites Culbertsonii, (fig. 2.)* Toes 4, and much resemble the preceding; the hind toe, however, is longer and more blunt at its extremity; the front ones spread at an angle of 70°. Length of the foot 4½ inches; length of the step uniformly 11 inches. The tracks were nearly in a straight line, and traceable for a distance of ten or twelve feet, the last step leaving a vivid imprint on the perpendicular side of the stone. This indicates that the position of the rock has been changed since these birds left their footprints on its plastic surface. The popular error, that these are the tracks of *wild turkeys*, needs no discussion.

The following species to figure 6, inclusive, may be the tracks of Saurians; yet this is only a conjecture. There is certainly some resemblance in these footprints to the order Digitigrada, but it is very improbable that animals of this division should be associated with aquatic birds, or that they should be even represented at this early period of our planet. They may constitute the new genus *Spheropezium*. The name is from σφαιρα, *sphere*, and πεζια, *sole of the foot.*

Fig. 3.



Reduced one half.

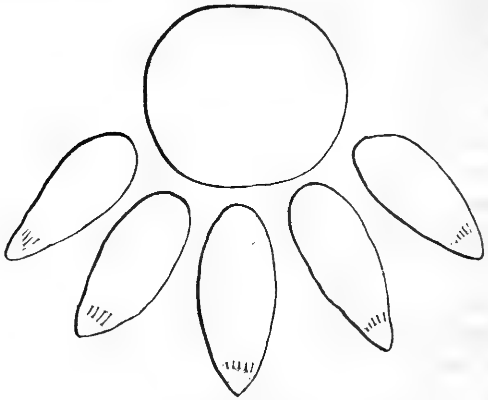
Spheropezium leptodactylum, (fig. 3.) Toes 5, spreading like an open fan, 160°; they are two inches long, and spread five

* This species I have named after my friend Alexander Culbertson, Esq., a gentleman of very acute and penetrating mind, who had the kindness first to direct my attention to these remarkable bird tracks.

inches, leaving an interval of one inch between each toe; the ball of the foot is round and nearly two and a half inches over.

Spheropezium pachydactylum, (fig. 4.) Toes 5, short and thick; the imprint of both toes and ball is deep; spread of the toes about the same as the preceding. The nails are perceptible on both tracks.

Fig. 4.



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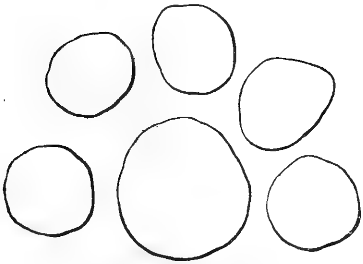
Spheropezium thærodactylum, (fig. 5.) Toes 5, spherical and subconical, arranged in a circle, spreading about 240°, or two thirds of a circle. The ball of the foot is also spherical, and nearly two inches across. The track is four inches each way.

Fig. 5, *b*.

Fig. 5, *a*.



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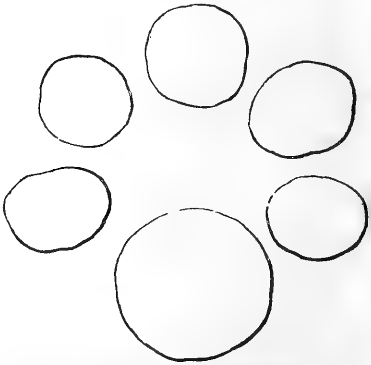


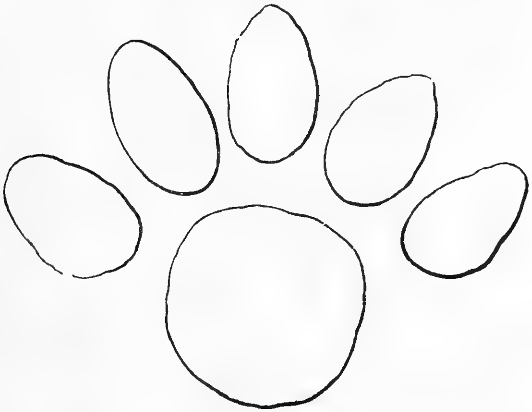
Reduced one half.

The length of the step could not be ascertained. In the specimen before us the ball of the foot is in the centre, the toes spreading regularly around it. (See fig. 5, *a*.) In other tracks, apparently

made by the same animal, the ball stands out and completes the digital circle. (Fig. 5, *b.*)*

Spheropezium ovoidactylum, (fig. 6.) Toes 5, making an ovoidal impression, spreading near 240°, about one inch long; ball of the foot spherical, nearly two inches across. Extreme spread of the toes nearly six inches. From the last character we may judge that this must have been the track of a very large animal.

Fig. 6.

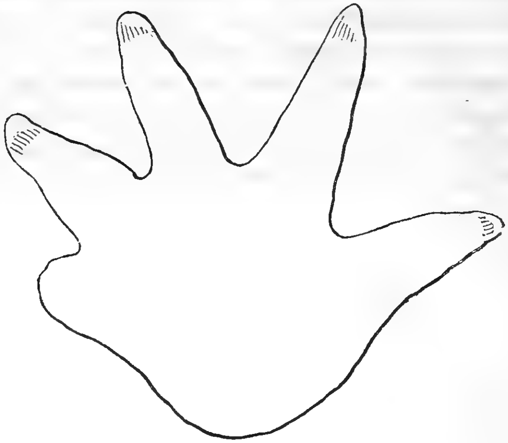


Reduced one half.

The rock on which the tracks above described were found, has an exposed surface of fifteen by twenty feet, rising like the other rocks in the neighborhood to the west, and dipping at a small angle to the east; it is a coarse-grained sandstone, about one hundred and fifty feet beneath the largest of our coal seams, and near eight hundred feet beneath the topmost stratum of our coal formation. From the existence of numerous holes or pots, some of which will hold fifteen or twenty gallons, excavated, as we know they are at the present day, by the whirling of pebbles set in motion by a running stream, I infer that the stone must have lain in the bed of a river which was subject to periodical fluctuations. These pots, which bear a striking resemblance to those now found in neighboring rivers, particularly in the Youghiogheny, were the objects of curiosity to the people of the neighborhood for years; but the tracks, though often noticed, were thought to be comparatively unimportant, as they were presumed to have been made by dogs, bears, wolves, wild turkeys, or other common animals.

* All these tracks are *depressions.*

Fig. 7, *a.*



Fore foot. Reduced one half.

Fig. 7, *b.*

Hind foot. Reduced one half.

In another locality twelve miles distant from that which furnished the preceding specimens, but in the same synclinal valley, on a slab of fine-grained micaceous sandstone, which was taken from a quarry about fifty feet lower than the tracks already described, I found beautiful imprints of the feet of a very different animal, as shown in figs. 7, *a*, *b* *c*. The hind and fore feet are

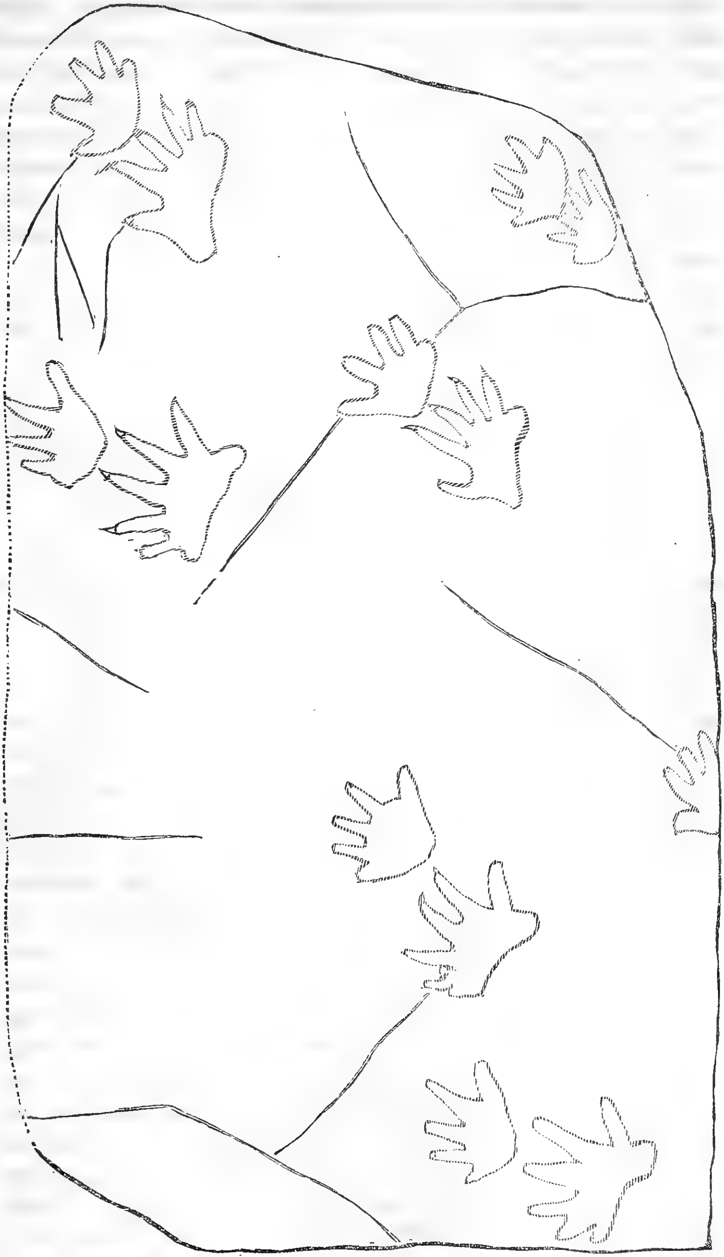
Fig. 7, *c.*

Hind foot. Reduced one half.

perceptibly different. On the hind foot the toes are 5, on the fore foot they are but 4. The plantar surface of the hind foot is long, narrow, and terminates in a distinct heel. The fifth toe, whose imprint is rather indistinct, stands out nearly at a right angle with the foot, and much resembles the human thumb. Indeed both feet look not unlike the imprint of a human hand. The length of the hind foot is $5\frac{1}{2}$ inches; the extreme spread of the toes $5\frac{3}{4}$ inches; the interval between them, from an inch to an inch and a half; the length of the toes about 3 inches. On the fore foot, the fourth toe stands out obliquely, like the fifth toe on the hind foot: length of the toes $2\frac{1}{4}$ inches; length of the foot $4\frac{1}{2}$ inches; the extreme spread of the toes $4\frac{3}{4}$ inches; the interval between them from one to two inches; the nails on some of the toes were quite distinct. At the external side of all the tracks there is a protuberance which much resembles the rudiments of another toe.

The imprint of the fore foot seems to indicate that the weight of the animal was sustained mainly by it, for the fore feet have made a deeper impression than the hind. I have given the average size of these tracks; a few were discovered, though not very distinct, which were some inches larger.

The following cuts represent parts of the slab from which the preceding figures are taken, on a scale of two inches to the foot.



The fore and hind feet follow each other very closely, there being an interval of about one inch between them. Between each pair of tracks the distance is six to eight inches, and between the two lines of tracks there is about the same distance. The shortness of the animal in proportion to its size, (for it must probably have weighed several hundred pounds,) the apparent sluggishness of its movements, and the difference in the number of toes on the hind and fore feet, seem to indicate an alliance with the Batrachians.

These tracks were all *in relief*, (casts;) I found but one that was a depression. The slab on which they were found was about five feet long, and three to three and a half wide.

Art. XIII.—*Idea of an Atom, suggested by the phenomena of weight and temperature;* by James D. Whelpley.

"I know not but the investigation we are now handling of the primary character of seminal and atomic particles is of a utility greatly superior to all others, as forming the sovereign rule of action and of power, and the true criterion of hope and operation."—Lord Bacon: *Thoughts on the nature of things. Th.* 11.

If there is any essential difference, between time, space, and force, and those perceptions from which they are abstracted, science must be concerned with the latter only, and in no instance with the abstract notion. Space cannot *exist* without matter; for we cannot *perceive* a space, in which matter is not present, more than a time, in which there is no change: Science being *a theory of perceptions*, it follows, that a scientific idea must be founded in the coexistence of time, number, substance, and form; its *objects* must have form, and its *changes*, a certain necessary order: it supposes that space is the form of substance, and motion the measure of time. "Matter stripped and passive,"* being a notion of little use, "the ancients therefore endowed the primitive matter with a form and properties." Democritus held, that "the atoms, or seeds, were like nothing that falls under the observation of sense, but that they were of a dark and secret nature; for he says, they are neither like fire, nor any other thing, the body of which is perceptible to sense, or open to the touch."

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* *Fable of Cupid*, Works of Lord Bacon, Vol. I, Am. edition.

"The natural motion of an atom, is neither that motion of descent, which is called natural, nor its opposite; nor one of expansion or contraction, nor rotatory, nor any one of the great motions simply. But, notwithstanding this, in the body of an atom are the elements of all bodies, and in the nature of an atom the beginning of all motions and of all natural properties."*

The Greek word *atomos* is usually taken to signify a particle; as though from *a* and *temno*, meaning 'a portion cut off:' but a more probable derivation takes it from the Sanscrit *atma*, a halitus, or spirit; whence also the Greek *atmos*, a smoke or vapor. But *atmu*, in the philosophy of India, signified the substance, or essence, out of which the world was made; and *purum atma* signifies Deity, or the pure Spirit, out of whom all things sprang, in the forms of nature, souls, spirits, and divinities.

The Vedanta philosophy, of which *purum atma* was the first principle and fundamental idea, originated in Indostan more than five centuries before the age of Pythagoras.

The philosophical idea of an atom,† requires, that it be composed of the very first principle of things; and since an atom is an idea, or notion, only, at the best, it is *composed*, if we may be allowed the word, of mere intellect; and this is the *atma*, or first matter; (for why should we confound *experience* of things, with an ideal system of science constructed from that experience?)

We know that invention, and judgment, work by ideas abstracted from experience; not by experience itself: for, if it were not so, the sage would have no advantage over the clown: Facts are valued, only in the service of ideas, being nothing, of themselves.

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* *Fable of Cupid*, Works of Lord Bacon, Vol. I, Am. edition.

† In a preceding article of this number, composed by Professor Hare, some extracts are given, from an article by Sir M. Faraday, published in the London and Edinburgh Philosophical Magazine; by which it appears, that I am partly anticipated, in this idea of an atom; as far at least, as regards the extension of the forces of atoms through space, and their partial interpenetration when chemically combined. Sir M. Faraday was also the first to show, that electricity is a motion propagated in the molecules of bodies. The famous hypothesis of Boscovich anticipates the opinion, that atoms are composed of *forces*, which extend through space; and the German "nature-philosophy" supposes, that the creation of things is effected by a resolution of the first principle into positive and negative, or masculine and feminine; an idea taken from the Hindoo shastras, and perhaps older than the pyramids.

By an idea, we escape empiricism, and begin to have a faith in the unity of things; invention, building upon this faith, anticipates Nature, and gives her forces new directions.

There can be no other test for the value of an idea, than the degree of order, which it brings, to the chaos of accidents. Testing, by this rule, the idea of gravitation, it discovers the greatest universality; but the notion of an ether, independent of matter, and able to impede its motion, seems wanting in the simplicity of a first principle. The ether of the mathematicians is only a more tenuous kind of matter, divided into particles. It is assumed, that these particles are centres of mutual repulsion, and, that they vibrate in a peculiar manner, producing radiant heat, and the motions of light; but no *cause* has been assigned for such vibrations, or why light and heat should not be as readily transmitted by an ether *not* divided into particles, as by one so divided. It is certainly as easy to conceive a *line*, as a *point*, from which repulsion shall originate equally on all sides; and a line of this kind, in motion, if it be a circle enlarging itself, might represent the motion of light and heat as truly as it is represented by a vibratile point; and it simplifies the idea of such a motion.

If any one can conceive of an invisible *force*, they can imagine that it operates in any mode or figure whatsoever. Let it be supposed, that there is a point (C) taken in space, which shall be the centre from which a force operates. If this force is spiritual, it may act in any direction it pleases; but, let it be material, then it must operate in fixed directions, and at certain intervals of time, and will be made sensible only when called into action by some other force, like or unlike itself, which acts from some other point in space. Suppose that there are but two such points from which these imaginary forces act, and that the powers which act from them are of the same kind, and that the two points are movable; then will they both seek to occupy the whole of space, (for they have the same relation to it,) and will retreat farther from each other, *ad infinitum.*

The conception seems to be of no use, for nothing comes of it; but thus much is gained, *that a force acting from a centre, may fill the universe with its presence, and will appear at all distances wherever another of the same kind* (or having the same relation to space) *may call it into existence.* The *points* are mere mathematical abstractions, but the *forces* are real ideas;

but they are only relative ideas, and signify that *two forces of the same kind cannot occupy the same space*, for, in nature, force, or substance, cannot be imagined without space, motion, and number, these being the conditions of its existence.

AXIOM. *All the conditions of existence are relative.*

Hence, the idea of the universe is that of a complex of relations, and science a system of such relations in the order of experience.

The same axiom shows the impossibility of the existence of but one repellent atom; for, repulsion is a relation between two substances which seek to occupy the whole of space, because they are of the same kind, (i. e. have the same relation to space.) In order, therefore, to conceive the existence of an atom that shall be the only one in the universe, we must imagine that it has two relations to space; in other words, that it is composed of two distinct substances. Every one believes, without argument, that there is a substance out of which all things are made, or, from which they originate, as ice originates from water; but if this "first matter" is all of a kind, and incapable of change, the idea of it is of no moment or significance. It must, then, be capable of change, in regard to space and number,—*it must be able to resolve itself into two kinds*, that it may begin to have a form and a diversity. Let (C) be a point in space, and the centre of an infinite sphere of influence, which diminishes in intensity from the centre outward, in the manner of gravitation. This influence is not visible, for it does not reflect light, nor is it perceptible by any sense; (for sense, unlike imagination, cannot regard existences or beings as wholes, but only in certain of their effects.) That such an idea can be formed, no one will deny; but it is, as yet, of no use and has no materialness, however much of spirituality. But now, let C resolve itself into *two* powers, or potentialities, infinitely intense at the common centre, and extended, in the manner of gravitation, through a common space. Since these powers occupy the same space from a common centre, they must be differently related to space, (i. e. they differ in kind;) but since, if they were of the same kind, they would mutually repel, so if they differ in kind, they will mutually attract, and satisfy, each other, seeking to fill the *same* space, from a common centre. An universe occupied by such atoms, would be an universe of death and silence; for, the two powers in each

centre, being equidistant from the same in any other centre, the attractions of the unlike are balanced by the repulsions of the like powers. But all things must have 'a beginning'—form must be given to the void, and motion to the dead.

That power which has resolved its first conception (C) into two others, a positive and negative, (which, while they satisfy each other from their common centre through all space, seem dead, and non-existent,) is able to give them a *form*, by causing the common principle* (C) to resolve itself in such a manner, that the positive and negative centres shall be on either side the common centre, at a certain distance apart, in any line passing through the centre of the infinitely extended atom.

Since all forces, being relative, develop each other, (either simultaneously, as substance, or successively as cause and effect,) the positive and negative forces of the original atom (C) develop each other, and are therefore *equal* in intensity. But the resolution of (C) extends through all space; the infinite atom is of such a nature that wherever the positive influence appears, the negative must appear simultaneously with it; and it is of such a *form*† that the centres at which these influences are most intense, are at a minute distance on either side of (C,) and this distance is the measure of a minute imaginary sphere about the centre (C,) and this sphere is the *nucleus* of the atom.

But things are distinguished by relative *force*, as well as by relative size. Hence two atoms may have the centres of their forces developed at equal distances from (C,) but with different *intensities;* and these intensities will be measured, as the weights of bodies are measured, by their mutual attraction and repulsion.

Inertia.

All the characters of an atom must be variable, but have a certain normal degree, about which they vary. Thus, the *intensity* of C's resolution into positive and negative being given, when the minute imaginary sphere or nucleus has a certain size, if the size increases, the intensity will diminish, and *v. v.* That is to say, the *total* force of the atom will remain the same, but be distributed in the surface of a larger sphere.

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* The *atmu*, or first matter; i. e. the thinking principle, intellect, acting in the figure of an infinite atom.

† Potentially.

But such changes will not pervade all space, but extend to a certain distance only from the centre; and the specific character of the atom is determined by a certain fixed relation, between the intensity of the forces (p and n) and the diameter of the sphere in whose surface they are developed. Finally, the *distribution* of this intensity may be different, at different times. Thus, if the (p and n) forces be developed, at the same instant, in three diameters of the atom, corresponding with the three dimensions of space, the intensities may vary in all three inversely as their lengths: that is to say, one diameter of the spheroidal nucleus may be longer or shorter than another; but if it be longer, its p and n will be *less* intense, and if shorter, *more* intense; so that a single atom may have three different axes, of as many different intensities, but whose intensities maintain a relation of compensation among themselves.

Such an atom may have a *motion* in regard to itself only, and not in relation to any other; for it has parts, and occupies all space, and can vary in three distinct modes; to wit, in the *size* of its nucleus, the *intensity* of its p and n powers, and the *form* of their distribution; but a change of one implies compensatory changes in all.

But it is of the first importance that if there be but one atom, or, if that atom be related only to itself, it can have but *one* axis in which p, n develope each other. For, let $p \overset{\mathrm{C}}{\underset{\cdot}{\rule{3em}{0.4pt}}} n$ represent an axis of polarity, developed by the resolution of C into two forces, whose centres of greatest intensity are p and n; and let $p\,n$ be the distance of these centres apart. The points $n\,p$ are movable toward and from C, in a vibratile motion. But, if n vibrates, p also must vibrate, and vice versa. If brought nearer together, they are repelled by C, if farther separated, they return to it; for these motions violate their normal relation to space. Let n vibrate toward C; a certain time must then elapse, before p can move away elastically on the other side, and, in that interim, C will have changed its position to the middle of the shortened axis p—C—n. Then follows an elastic motion of p, equal to the first one of n, and C follows it, moving as before in the same direction, and so on. The centre (C) must continue to move in this manner, and the force with which it moves is exactly equal to the communicated impulse, (because all forces de-

velop each other,) and the force which developed p and n, was also the force which put them in motion.

Now, an atom left to itself, and related to itself only, and to the parts of space, can have but one such axis of vibration. For, if two such be developed, at any angle with each other, the mutual repulsions $p\,p'$, $n\,n'$ of the two, and their mutual attractions $p\,n'$, $p'\,n$, will cause them to coalesce in a common axis: In general, *if two axes be developed in a single atom, and at the same instant, they will combine to form a third, according to laws of the composition of forces.*

It follows, that an atom moving by itself, by reason of a communicated vibration, can move only in a straight line; *and this is the line of inertial motion.*

Gravity.

Gravity causes all bodies to vibrate in the line of attraction. For, if one body be attracted by another, all parts of it are caused to move at the same instant; but the parts nearest to the attracting body are more intensely affected than the more distant parts; and the consequence will be, a slight separation among the particles of the attracted mass; and the elastic return of the particles will give rise to a vibratile motion of the whole mass. But single atoms will be affected in the same manner with masses; for the nucleus of an atom has dimensions, and the nearer are more intensely affected than the more distant parts. Gravity, therefore, may communicate the *inertial motion* to an atom, causing it to move in a straight line toward the cause of attraction; and though the cause of the first motion be removed, the vibration, and consequently the rectilineal motion must continue.

When two atoms of the kind described are present to each other in space, they will excite or polarize each other.

Let C and C′ be the nuclei of two gaseous atoms,

$$p \overset{C}{\text{———}\cdot\text{———}} n \qquad\qquad p' \overset{C'}{\text{———}\cdot\text{———}} n'$$

floating free in space, which they fill by their extension. If there were only one such atom, C would *not* be resolved into $p\,n$. If there were two such, and their C's unresolved, they would have no motion; the attractions of the *dissimilar* forces, pn' $p'n$, would balance the repulsions of the *similar* kinds, pp' nn'. But if the resolutions of C and C′ have taken place in single axes, as repre-

sented in the diagram, the attractions np', pn', must overcome the repulsions nn', pp', being greater than they; (because these forces vary as the square of the distance inversely, the attraction np', together with attraction pn', is able to overcome the repulsions:) C and C′ will consequently approach each other. But if one only of the atoms is developed into p and n, it will cause a similar development in the other. For, these forces develope each other, and the influence np', and the repulsion nn', will together cause p and n to appear in the common axis of the two atoms.

But this effect happens at the same instant along the whole line passing through the centres C C′; for the forces pn, $p'n'$, are present along the whole of that line, though their points of greatest intensity are in the surface of the nucleus. It is, therefore, necessary to the motion of gravity, that one of the C's shall have been resolved into pn, by some other cause, and the beginning of all motions must be referred to a divine will. Two single atoms of the kind described, should act toward each other as masses act when they gravitate.

The inertial vibration, which is a relation of motion in the parts of the nucleus, may be continually changed in its direction by the development of another axis at an angle with it, producing motion in a curve. The curve of revolution described, will measure the relation of the two forces, both as to their directions and their intensities; but the motion which they occasion, cannot be regarded as absolutely continuous, or strictly curvilinear, for it is composed of vibrations.

Temperature.

When the nuclei approach so near, that n coincides with p', as in $p \overset{C}{\text{———}} np' \overset{C'}{\text{———}} n'$, they must cease to approach nearer; for if they were forced to *penetrate* each other, so that n should pass by p', the joint effect of nn', pp', and $p'n$, would be to prevent such a movement, and convert the attraction of the two into an elastic repulsion. This may be the case of two *gaseous* atoms, which have approached until p' and n coincide. But because the external p and n' continue to act, and still press the centres nearer, the two nuclei will be slightly diminished in size, and gain proportionately in elasticity and intensity. Since it is cer-

tain that the atmosphere absorbs a certain quantity of solar influence, it may be assumed that gases have a feeble power of radiating heat, absorption and radiation being equal. The two atoms will consequently radiate a heat proportionate to their condensation. But this radiation seems to be only an effect happening in the atom itself. For, because the normal size of the nucleus pn, represents a relation of the atom to itself which pervades all space, if that relation be changed, the whole atom will share in the change. If the central nucleus contracts by *pulses*, or minute vibrations, these must be radiated from it in the manner of waves traversing space like the radiant pulses of light. But why are not these waves the same with those pulses? Assuming their identity, *there would then be no place for an hypothesis of a peculiar ether of light and heat; since the atoms do of themselves constitute an ether; for they pervade all space.*

Assuming that the temperature of an atom is an expression for the diameter of its nucleus, if two atoms $p\overset{C}{\underset{\cdot}{\text{——}}}n$ $p'\overset{C'}{\underset{\cdot}{\text{——}}}n'$, are in contact, but of different temperatures, their forces will react in such a manner, that the difference shall be divided between them; $p'n'$ will contract, and pn expand, the distance between their centres remaining constant. *And this will represent the restoration of the equilibrium of temperature by contact of particles of the same kind.*

But if the atoms are *not* of the same kind, (that is to say, if the relation between the size of their nuclei and the normal intensity of their polarities, (for that size,) be not the same,) the equilibrium will be restored, and yet a difference of size or of intensity may remain. *And this difference will represent the ratio of the specific heats of the atoms.*

When two nuclei are brought into contact with each other at different temperatures, one of them contracts as the other expands; the *contracting* nucleus will radiate "heat pulses," and the *expanding* one "cold pulses;" and the two kinds of radiation, like opposing pulses of sound, will exactly cancel each other; and no heat will become sensible. The outflowing or "heat pulses," propagated through the whole of space with a certain mensurable velocity, will cause expansions in other nuclei through which they pass.

If in any two atoms of the same kind, $p\overset{C}{\text{———}}n$, $p'\overset{C'}{\text{———}}n'$, acting from a distance, $p\,n$ is shorter than $p'n'$, it is of a different temperature, but of the same gravity, the intensity $p\,n$, being greater as the diameter $p\,n$ is less. *The gravity of the two atoms will, therefore, be unaffected by their differences of bulk,* (i. e. of temperature.)

There must be a temperature at which an atom ceases to radiate, or attains its normal bulk, than which it may be either less or greater, and toward which it constantly tends. This temperature is the normal dimension of the nucleus, relatively to that of all other nuclei. If C therefore be less than its normal bulk it will expand, radiating "cold pulses." The relation of C to C′ is such, that as soon as this difference in the one atom is felt at the nucleus of the other, a compensatory change must happen in this latter; as in the instance of contact. The radiant pulse is "absorbed" by the nucleus; which thereupon *contracts*; or, if the radiation be a "heat pulse," it *expands*.

But the phenomena of radiation require a minuter examination than would be consistent with the purpose of this article; which is to show the possibility, only, of the idea of an universal atom, that shall serve as a basis for calculation.

Since a smaller atom should move and change its temperature by shorter pulses, and the red rays are known to be the shortest visible rays, the nuclei of all atoms at a red heat should be of one and the same diameter. Gases and liquids, being for the most part blue, should originate longer and feebler pulses, because the nuclei of their atoms are larger. Facts like these suggest the possibility of finding the dimensions of the atoms; for we know already the lengths of the pulses of light, and the nuclei must be larger than the pulses they excite.

The three conditions, liquidity, solidity and aeriformity.

The theory of comets, and of planetary atmospheres, rests upon the hypothesis of a mutual gravitation of gases. Let it be assumed that the nuclei of two atoms of gas floating free in space will approach each other, until, at a certain limit, their attraction is converted into repulsion. This limit will determine the size of their repellent nuclei.* Change of temperature being only a

* "Atmospheres of repulsion," if the word *atmos* is taken to mean pure force, as if from the Sanscrit *atma*.

diminution of these nuclei, the 'cooling' of the two atoms by radiation will bring them nearer and nearer, their slight excess of attraction gradually overcoming their repulsion. But if they be such gases as oxygen and nitrogen, and therefore not condensable by the cold of space, this diminution will cease before they can become *liquid.*

The cohesion of liquids gives minute drops of them a spherical shape, showing that their attractions are equal in all directions, in the manner of gravitation: nor should this attraction be any other than the mutual *gravity* of single nuclei, grown more powerful by their near approach. (The sizes of liquid drops will therefore measure the intensity of the attractions of their single nuclei, (i. e. will measure the weights of the atoms,) supposing they are all of equal size.)

But when two gaseous nuclei are cooled in contact, their repellent spheres do not actually interpenetrate, so that one encroaches upon the other; for, when a gas is condensed, bodies in contact with it become *heated*, (i. e. expanded,) showing that the gaseous nuclei have *contracted*, and that the solid surface in contact with them expanded proportionately, to sustain the equilibrium of temperature.

The middle n and p' continue, therefore, to coincide, as long as the nuclei may be in contact, through all changes of temperature.

Since, then, the attraction of liquid atoms differs in no respect from gravity, there remains only one other species of attraction to be considered, namely, the crystalline, giving rise to *solidity.*

Crystalline attractions are stronger in certain lines and planes, an inorganic solid being always more fragile in some directions than in others. These directions are indicated by "planes of cleavage," which form certain angles with each other; and these angles of fracture are invariable, in crystals of the same substance, at the same temperature.

To account for crystallization, (i. e. solidity,) let it be supposed, that there are but two modes of aggregation, one, that of *liquids*, and of gravitant atoms in general, the other that of *solids.* Since, in any atom, the two forces, into which C has resolved itself, are related to each other as positive and negative, they tend always to an equilibrium, or equal diffusion, so that the same degree of each shall be potentially present in any part of

the atom. But the presence of another atom disturbs this equilibrium, by causing a feeble development of the two forces in p and n. If more of one kind is developed at p, an equal force of the other must be developed at n, to sustain the equilibrium. But, even in liquids and gases, the axes of relation are in certain lines which pass through the nuclei of several atoms, and form series of positive and negative poles, (like lines of magnets,) as may be surmised from the phenomena of electric excitation. A nucleus between two others presents a positive pole to one, and a negative pole to the other, and a great number of liquid or gaseous nuclei in an independent mass, must take a spherical shape. In a mass of spheroidal nuclei each individual will be touched by those about it at *six* different points, which are the extremities of *three* axes, answering to the three dimensions of space.

Now, as it happens, that when a number of gaseous atoms approach to a certain nearness, their attraction changes to repulsion,—so, when their centres are brought still nearer by the 'cooling' or diminution of the nuclei, their attractions are developed in a different manner. The two forces which, in the gaseous and liquid nuclei, strove to develope themselves equally in the whole of the nucleus, suddenly *concentrate* themselves in the three axes of solidity, and the atoms become *fixed* in geometrical figures; in other words, they crystallize. It was assumed, that the gravitant attraction should have a certain *intensity*, which should be characteristic of the atom; and it is equally necessary to be assumed, that when the nuclei are reduced to a certain nearness, their mutual effect will be the development of (C) in three distinct axes, forming the three dimensions of a crystal. That this mode of development is a *specific* property of each atom, is proved by the fact, that crystals of the same substance have always the same form. This *form* will vary according to the lengths of the crystallogenic axes; for, if temperature is the *diameter of the nucleus*, we may imagine a law by which the temperature is divided among the axes so that they shall have different lengths; the *shorter* will be those of intensest cohesion—the *longer* will be the feebler, and therefore at right angles to "planes of cleavage." That a certain necessary relation will exist between the *form* of an atom (i. e. the relative

lengths of the axes) and its bulk, is certain; but, to establish such a relation, the facts of chemistry must be appealed to.

The *temperature*, at which atoms may develope the three axes of solidity, is not the only condition of their solidification; for it is well known that the *solids* of many substances occupy more space, than the liquids from which they crystallize; and water may be cooled without freezing, far below its freezing point; and when any part, of such a mass of water, begins to form crystals, it raises the temperature of the rest. It follows, that, in general, *nuclei in contact cannot develope their solid axes,* (i. e. cannot increase the intensity of their polarities in those axes,) *without diminishing to an equal degree that of bodies in immediate contact with them;* and this diminution is balanced by an increase of bulk, (i. e. of sensible heat,) so that freezing liquids actually cause an *expansion* (heating) of bodies in contact with them. It is difficult to show the nature of this relation, between the increase of axial intensity in a solid, and the diminution (or cooling) of its mass; meanwhile, *that there is such a relation*, is evident.

Electricity.

That the polar forces of gaseous nuclei are the same with those of solids, is proved by the electric excitation of air by electrified surfaces.

The "conduction" of electricity, though it occupies time, is clearly not a *conduction* in the usual sense of the word, but *is the restoration of an equilibrium.* An insulated electrified body is known to be in the electric relation, not only to objects near, but *to the whole of space;* for its influence diminishes as the distance square, inversely, in the manner of gravitation. The *excitation* of one body by the presence of another, is effected by the intervention of air; for it has been long known, that a rare atmosphere suffers the passage of electric influences, more easily than a dense one. If a space could be freed of air, it would therefore permit the instantaneous restoration of the electric equilibrium through its vacuum; and magnets act upon each other through all obstacles;—considerations which show, *that the polar forces of every nucleus are in a relation of equilibrium with the forces of every other atom near or far.* But this relation is one of *intensity*, and of this intensity there are two kinds; corresponding

with the two kinds of forces whose difference of *distance* occasion the relation of gravity. Let two gravitant atoms,

$$\overset{C}{p \overline{\quad\quad\cdot\quad\quad} n}, \quad \overset{C'}{p' \overline{\quad\quad\cdot\quad\quad} n'}$$

have the forces $p\,p'$ developed *in excess* over those of $n\,n'$. *They will begin to repel each other, when that excess surpasses the force of their mutual gravitation.* But if p is developed more than n, it must be at the expense of n. Now, take away the cause of this excessive development of p or n, and the equilibrium will be instantly restored, and the forces be equal; as before. There are, then, two kinds of repulsion, that of $p\,p'$ in excess, and that of $n\,n'$ in excess, *corresponding with the repulsions of positively and of negatively excited bodies.*

Attraction will be occasioned by the excess of one of the powers, (p for example,) *in one of the atoms.* If n be in excess, the force of p is proportionately diminished; and the result is, that, while the cause of this difference continues, repulsion $p\,p'$ is diminished, as much as repulsion $n\,n'$ is increased; but, that attraction $n\,p'$ is increased more than that of $p\,n'$ is diminished—a difference remaining in favor of the attraction $p\,n'$. This, then, is the *cause* of electrical attraction. But if the cause of this disturbance is removed, a resolution instantly follows. Such resolutions must take place across vacant space, for the atoms C C′ develope each the forces of the other. Electric discharge is this resolution of $p\,n$, and, *that there is a constant tendency to such a resolution, is proved, by the fact, that* $p\,n$ *develope each other equally in an isolated moving atom.*

General conclusions.

If it is enquired, *why* the forces of an atom shoot into crystalline axes, the answer is, that if such an event is brought about in one atom, it must of necessity happen in others that are in immediate contact with it, for all forces develope each other.* In physics, motion has neither beginning nor end, and the *cause* of every motion is a previous one of the same kind. That a nucleus may assume any state, it needs only to be in contact

* It is at present necessary to assume, that when the nuclei are contracted to a certain size, their forces will be axially developed: but the law is not without exceptions, and therefore must, (like gravity,) admit an analysis of its causes.

with one already in that, or in some *analogous** state. The *conditions* of that contact, we name *temperature.*

Between gaseous nuclei electric resolution cannot always happen. *The mutual repulsion of gases depending upon the tendency of p n, to an equal distribution in the nuclei of their atoms,* (a tendency which marks their relation of temperature,) *a certain intensity of the electric condition is required to overcome it.* The force of an attraction is a geometrical mean, between the two attrahent powers. Hence, the nucleus of a gaseous atom will come vastly nearer to that of a *solid,* than to that of another *gaseous* nucleus; the difference may amount even to solidification, (by the development of its solid axes, under the influence of those of the solid atom.) Let a gaseous nucleus be so near, and so powerfully affected by the *positive* excess of a solid nucleus, that it is not only attracted with more than the normal force, *but has the equable development of its forces disturbed from the centre, so that its relation to the whole of surrounding matter is changed; it is then electrified,* (negative or positive,) *and repels others that are electrified at the same instant and in the same manner.* If this condition have a certain *intensity,* one gaseous nucleus may *divide* its condition with another, by *the spark;* in which, a line of nuclei polarize each other and simultaneously.

But a line of gaseous nuclei between positive and negative poles, prevents a resolution of these poles until the intensity is so increased as to cause a spark; for they resemble a line of temporary magnets, and the last one in order *induces* an excitation in the solid with which it is in contact, opposite in kind to that which it receives from the distant excited body, so that the intervention of unexcited gaseous nucleus must prevent a resolution of opposite excitations.

The excitation of a gaseous nucleus depends upon the intensity of the polarizing influence, (*and that intensity must be at least equal to the intensities of its axial forces in the solid state,*) as well as upon the nearness of the nucleus to the solid electrifying surface.

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* I mean to say, that a gaseous, or liquid, nucleus of one substance, may cause solidity in another substance, without becoming solid itself. Thus, hail formed in air at 32°, &c.

Chemical combination.

The idea of *cohesion* is that of a resolution into forces, which act at the extremities of the three axes of the nucleus. Single atoms must have but one centre. Let a nucleus of gaseous chlorine be nearly in contact with one of hydrogen. Let them be together as part of a chain of mutually electrified nuclei: then, let them be affected, and affect each other, to that degree that solid axes are generated in them. They will then cohere; but this is not like common cohesion—for, becoming instantly gaseous by the heat developed about them, *they remain in combination, and act, as though they were a simple atom, with a single set of axes.* To form an idea of such an atom, we may suppose that different elementary atoms, chlorine, hydrogen, &c., are affected in different degrees, by the same cause. For, if it is supposed that crystalline *cohesion* is an effect that can happen only between atoms in every respect equal and alike, (as is certain by the idea already given of it,) the mode of combination between unlike atoms will be different from cohesion, in the degree of their unlikeness. Suffice it to say, *that this difference consists, probably, in a nearer approach of the centres of the two atoms, and in the formation of an ellipsoidal, or spheroidal, compound nucleus, by the resolution of the two systems of poles into one system, enabling them to act as a single atom.** A fuller exposition of this and other points of the atomic theory, is reserved for more leisure.

Recapitulation.

The idea of an atom, like that of an element, must satisfy all the conditions of time, space, and number; and must be composed of two forces which originate from a common principle, or substratum; and since that principle fills all space, the powers of the atoms, which are formed by its resolution from certain centres, may extend through all space. *An atom, therefore, is* in a material sense *omnipresent.* The two forces into which an atom resolves itself, if they develope each other, are necessarily *equal;* they operate from the extremities of the di-

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* I am sustained in this view by the crystallographic hypothesis of Mr. J. D. Dana, as it is given in his Mineralogy. He supposes, that compound molecules are spheroidal or ellipsoidal, like the nuclei of simple atoms.

ameters of the nucleus of an atom—the dimension of that nucleus is its *temperature*, specific or relative. The *forces*, extended through space, diminish in intensity as the square of the distance from their centres. When the forces of one atom develope those of another, the two must *gravitate*. An atom left to itself *can have but one axis of forces*, and the inertial motion of bodies is the *vibration* of an atom in that axis. The *whole* repellent or attrahent power of an atom from its centre outwards, is the same at all distances from that centre, (outside the nucleus,) for it diminishes as the distance square, being only 'diffused' in the surface of a sphere of which the nucleus is in the centre. *Aeriformity is caused by the tendency of the two powers of an atom to satisfy each other*, *and be equally present in any point in the surface of the nucleus;* the rise of temperature is the extension of the limit of this tendency, i. e. the expansion of the nucleus. The nuclei never penetrate each other, but when compressed, diminish; their diminutions are exactly balanced by the expansions of those in contact with them, (i. e. they give out "sensible heat.") As the nuclei diminish, the intensity of their polarities increases proportionately; and all changes of this nature happen by *pulses;* and these pulses move outward into space, causing light, and radiant heat. *Liquidity* is the state of equilibrium, between solid and gaseous. *Solidity* is the development of the forces of an atom in the axes of the nucleus; this development is caused by the mere "contact" of nuclei already solid: or by that of other liquid or gaseous nuclei, of the requisite temperature. Solidity is therefore the exact opposite of aeriformity. *Electricity* is a disturbance of the two forces of an atom, by which one is increased at the expense of the other. Chemical combination is the resolution of the forces of two or more atomic nuclei into a single set of forces acting like those of a single atomic nucleus; *but the centre of one atom cannot perfectly coincide with the centre of any other atom.* *All* the properties of an atom are variable, *and a change in one, causes compensatory changes in all.* These properties are, the *distance*, *intensity*, *change of distance*, and change of intensity, by motions *vibratile and pulsatile.* To discover the laws of these changes belongs to the mathematician.

ART. XIV.—*On the hypothesis of Mr. Prout, with regard to Atomic Weights;*—in a letter from BERZELIUS, dated Stockholm, Dec. 6, 1844.

Remark.—The following is the translation of a letter received from Berzelius, in reply to a request from the Junior Editor of this Journal, that he would favor its pages with an expression of his views on this much mooted question. The reader cannot fail to admire the candor of the distinguished author, and at the same time must admit the justness of his views.—*Eds.*

IN scientific questions, errors are avoided only by making experiment the basis of opinions. Mr. Prout, in bringing forward his views, based them, on the contrary, upon a presumed inaccuracy in experiments made for determining atomic weights. It seemed to him convenient and advantageous to science, that the atomic weights should be expressed by small numbers, and without fractions, and as the weight of hydrogen was relatively much below the others, he proposed to secure this simplicity by considering all a multiple of the atomic weight of hydrogen; and in carrying out these views, he found that it required but a small change of the ascertained weights, not greater than was deemed unavoidable errors in analyses.

The basis of Mr. Prout's hypothesis, then, is the supposed inexactness of experiment. The seeming correspondence with it which oxygen and carbon afforded, was thought to authorize a correction of the other atomic weights, so as to make them accord with his hypothesis, although but a mere hypothesis, not verified by observations in the great majority of instances.

Mr. Prout has given no explanation of the supposed fact on which his theory is based. Such a result could hardly proceed from any thing but the existence of only a single ponderable element—hydrogen—of atoms of which combined, the compound molecules of all the other so-called elements must consist—each of some definite number. In such a case, whatever be the attraction uniting the atoms in their compound molecules, we might have expected that in the course of the 1300 years since the alchymists commenced their experiment, or under the more

skillful research of the modern chemist, some instance might have come to light, in which an atom should become detached from a given compound molecule, or another added, and in one way or the other a new element have come to light. But no instance of this is known: the elements have remained unchanged—incommutable.

Dr. Thomson endeavored to establish Mr. Prout's hypothesis, by a series of experiments; but his investigations will not bear even the most superficial examination; yet they contributed much to give popularity to Mr. Prout's ideas in England and also in other countries. Subsequent to this, Prof. Turner was deputed by the British Association, to determine the atomic weight of certain of the elements, in order to settle the question. You, perhaps, recollect that his labors gave but negative results, and this able chemist finally abandoned the hypothesis.

The discussions, however, did not terminate here. The atomic weight of carbon caused their renewal. I obtained for its equivalent, by chemical experiments, 75·33. The method by calculation from the specific weight of carbonic acid gas, I at that time rejected, as I had found that sulphurous acid gas, being condensable, gave the atomic weight of sulphur much too high. But some years afterward, on examining with Dulong the specific weight of carbonic acid gas, at that time not known to be capable of liquefaction, it seemed to us that the method by calculation, would lead to surer results than direct experiment. Admitting that oxygen gas alters not in volume, when converted into carbonic acid gas, we deduced for the atomic weight of carbon 76·438—a number soon very generally admitted. A few years subsequent to this, however, it was discovered that carbonic acid gas, far from being permanent, was condensable; but no one then dreamed of the influence which this would have upon the result obtained by calculation. But after a while it was found that the atomic weight thus deduced was much too high. Dumas undertook new experiments, and arrived quite exactly at the number 75, which, as it is just 6 times the weight of hydrogen, gave a new impulse to the hypothesis of Prout. He examined the atomic weight of hydrogen, and by experiments made apparently with much care, arrived at results a little varying, from which he adopted 12·5—the same that Prout had obtained by dividing the

atomic weight of oxygen by 8. By new experiments upon oxygen, nitrogen and atmospheric air, he went on to show other coincidences with the hypothesis of Prout.

These researches engaged another chemist, M. Marignac, to undertake a series of experiments upon the atomic weights of chlorine, bromine, iodine, nitrogen, potassium and silver. His incomparable researches are a *chef-d'œuvre*, as much for conscientious exactness as for the judicious and varied methods employed. The results approach multiples of 12·5, but to make them precisely so, requires larger corrections than the greatest variations in the results of experiments. One alone, that of bromine, is very nearly 80 times 12·5. The atomic weight of chlorine, found to be 443·2, varies from 447·5, the nearest multiple, by too large a quantity, to be an error in experiment. Marignac was of the opinion that his experiments did not settle the question at issue, as the approximation to the hypothesis of multiples was still quite close; but in the case of chlorine he admitted that there was an undeniable exception. He endeavored, however, to make an approximation to the hypothesis of Mr. Prout, by comparing the weight of two atoms of chlorine with one of hydrogen, in which he found the former to be almost exactly 73 times that of the latter.

But let us examine whether it is proper to view them in this relation. You know that nearly all English chemists, and also many others, consider water a compound of an atom of each element, notwithstanding the fact that the amount of hydrogen gas is in volume double that of oxygen; and this view is adopted because it is the most convenient, although mere convenience cannot establish the truth in the case. It is well known that several simple bodies combine with oxygen in such a manner that the molecule of the oxyd sometimes contains one, sometimes two atoms of the radical, as an example of which I mention here the series, $Mn+O$, $2M+3O$, $Mn+2O$, $Mn+3O$, $2Mn+7O$. There is no doubt that the last, the hypermanganic acid, contains 2 per cent. of the radical. It is besides known that the *hypermanganate* and *hyperchlorate* of potassa are isomorphous. From this it follows conclusively that the hyperchloric acid contains also 2 atoms of chlorine for 7 atoms of oxygen. It must hence be an error to consider two volumes of chlorine as

a single atom. You know also that chlorine combines itself with hydrogen only in equal volumes, and that in the great number of isomorphous compounds in which chlorine is substituted for hydrogen, without a change of crystalline form, this substitution takes place invariably under equal volumes. We cannot, therefore, avoid the conclusion that *two* volumes of hydrogen as well as of chlorine, represent *two* atoms, and consequently an atom of water contains two atoms of hydrogen, just as one atom of cuprous oxyd, mercurous oxyd, and hyposulphurous acid, &c. contain two atoms of the radical. It therefore follows—and not equivocally—that chlorine and hydrogen cannot be compared except in the relation of equal volumes, and consequently the atomic weight of chlorine cannot be a multiple of that of hydrogen.

In glancing over the table of atomic weights, you will find numerous exceptions to the hypothesis of Mr. Prout. It is true that the most of these numbers have been determined by experiments made 30 years since, and at the first development of chemical proportions. They cannot, therefore, have all the exactness which they might have with the new analytical processes since discovered. But I am persuaded that they will be found, with few exceptions, to approach quite near the truth, and not to admit of that latitude of correction demanded by Prout's hypothesis. I cite, for example, the atomic weight of lead, which has been the subject of reiterated experiments in the course of this discussion, and which has been fixed at 1294·5—also that of copper 395·7, both lately verified by Messrs. Erdmann and Marchand. To accord with Mr. Prout's hypothesis, the first ought to be 1287·5 or 1300, and the second 387·5 or 400.

Among the atomic weights there are those which are apparently equal, and others which approximate quite near to being double of one another in weight—from which it is probable that there is between them a certain relation; but these pertain only to particular groups of the elements—such as the metals which accompany platinum,—molybdenum and tungsten,—chrome, iron, manganese, &c. But this is a new question, to be discussed only after farther investigation.

Yours, &c. Jac. Berzelius.

ART. XV.—*On the Drift Ice and Currents of the North Atlantic, with a Chart showing the Observed Positions of the Ice at various times;* by W. C. REDFIELD.*

OF the various dangers which beset the path of the mariner, perhaps there are none which excite to more vigilance than the known or expected proximity of ice. In some frequented portions of the Atlantic Ocean the ice appears almost every year, in the various forms of field ice, floes and massive ice-islands, drifted from the arctic regions by the constant action of the polar currents. These ice-bearing currents, in flowing towards the south, must necessarily incline towards the western limits of the ocean, owing to the increased velocity of the diurnal rotation of the earth's surface as we depart from the poles; a law well understood as regards the currents of *air* which form the trade winds. Hence it is that on and near the Banks of Newfoundland these ice-currents are found to cross the usual track of vessels bound from the ports of Europe to northern America.

The quantity of ice which appears on this route of navigation in different years, is exceedingly various. It is sometimes seen as early in the year as January, and seldom later than the month of August. From March to July is its most common season. It is found most frequently to the west of longitude 44°, and to the eastward of longitude 52°; but icebergs are sometimes met with as far eastward as longitude 40°, and in some rare cases, even still further towards Europe.

Experience has shown that the proximity of ice is far less hazardous than rocks and shoals; and this floating danger would be still less formidable were it not for the fogs and mists which it often causes. The *thermometer* has been often held up as affording sure indications of an approach to ice, by the reduction of temperature shown both in the air and water, and these indications are important and should by no means be neglected. But there may be many cases of approach to ice where a reliance upon the thermometer alone could not afford security.

On the ice chart, which is annexed, we have indicated numerous positions in which ice has been seen and reported on the

* From the forthcoming "Memoir" of Messrs. E. & G. W. Blunt on the Dangers and Ice of the North Atlantic Ocean.

common route of navigation, chiefly since 1832. This will serve to show the region where it is most often encountered.

Although little or no ice be seen in one passage, or even in many times crossing the Atlantic, yet it has been frequently met in such quantities as seemed to indicate a vast, or indefinite extension of the ice-fields, towards the polar seas. And from the inexhaustibility of the sources of supply, and the permanent character of the polar currents, we may infer that there is no spot of ocean within the influence of these currents which has not, at some time, been covered with ice.

A recital of the various authorities and marine reports from which our ice-chart has been compiled, might prove more tedious than useful. The following, however, selected from many others, may serve as examples of the cases in which the ice has been noticed by navigators.

Ship Eli Whitney, Harding, April 7, 1836, sea account: wind S. S. W. and thick fog; ordered the temperature of the water to be tried every half hour; at 6 P. M. water 36°; passed a small ice-island; ship going west all night three knots; 6 A. M. water 34°, at 8 A. M. water 31½°, passed considerable quantities of ice. At 10 A. M. saw a large field of ice ahead, which extended to the north and south as far as the eye could reach; entered it in expectation of finding an opening to westward. After proceeding a cable's length, wore round and stood out as we went in, and then hauled the ship on the wind to the S. E. Longitude by account, 47° 06′ W., latitude by account, 44° 41′ N.—April 8, wind S. S. W., stood to the S. E. till 5 A. M.; water 46°; tacked ship to the westward. At noon water 44°, latitude by observation, 44° 35′, longitude by chronometer, 46° 56′.—April 9, wind S. S. W. and foggy. At 4 P. M. water 34°; wore ship to the S. E. At midnight water 44°; tacked ship to the westward. At 8 A. M. wind shifted N. W. and cleared off the fog; three large islands of ice in sight; water 44°; latitude by observation, 44° 17′ N., longitude by chronometer, 47° 50′ W.—April 10, wind N. W.; passed six large islands; water in vicinity of the ice 40°, latitude by observation, 43° 09′, longitude by chronometer, 48° 55′.—April 11, passed four large islands of ice this day; at 8 A. M. sounded and found bottom with 42 fathoms; water 35°; latitude at noon by observation, 43°; longitude by chronometer, 50° 36′ W.

Ship Samuel Wright, Allen, March 18, 183–. Latitude 43°, longitude 48° 43′. At 3 P. M. very foggy, came nearly in contact with a very large island of ice, about 150 feet high and one mile in length; the weather extremely cold, kept the ship under easy sail. At 5 P. M. fell in with an English brig, and were informed we were standing for more ice, and that she had been for five days surrounded with it, extending from latitude 45° to 43°, and found no opening to the westward. Kept company during the night, and fell in with more ice; in the morning no ice in sight.

Ship Fama, Winsor, March 183–, in latitude 44° 30′, longitude 48°, fell in with an immense field of ice; tacked ship to the eastward and stood off and on two days. Wind changed to N. E., and run 45 miles S. W. and passed the point of ice in latitude 43° 25′, longitude 48° 50′.

The British Tar, Hanby, left the Gulf of St. Lawrence 29th June, and passed through the Straits of Belle Isle. On the 3d of July, about 15 miles eastward of Belle Isle, found the passage quite blocked up with very heavy fields of ice, which obliged us to put back to an anchorage. On the 6th again made the ice, and found it more open: passed through about seventy miles of it. On the eastern edge, fell in with nine brigs, a ship, and a barque, standing off and on, waiting for a passage into the straits. The icebergs were very numerous and immensely large, as far to the eastward as longitude 48°.

Ship Oneida, Funk, May 4th, 1841, latitude 43° 40′, longitude 50°, passed a number of large icebergs; saw ice as far west as longitude 53°.

The brig Anne, of Poole, William Dayment, master, sailed from Greenspond, Newfoundland, [N. E. coast,] 19th of January, 1821, and in the evening encountered several floating islands of ice. On the following morning, at sunrise, the ship was so completely enveloped in ice that there appeared no means of escape, even from the tops of the masts. The ice, in its whole extent, rose about fourteen feet above the surface of the water; it drifted towards the southeast, and bore the ship along with it twenty nine successive days. On the 17th of February, Capt. D. being three hundred miles east of Cape Race,* in latitude 44° 37′

* That this position was ascertained by chronometer appears doubtful.

north, perceived an opening to the southeast, and succeeded in disengaging himself. From the 29th of January to the 3d of February, the brig only made four miles a day; and during the twenty nine days this navigation lasted, he descried near one hundred very extensive mountains of compact ice.

Ship Isabella, Meredith, struck an iceberg on 9th May, 1841, in latitude 42° 2′, longitude 43° 45′. The iceberg broke through the bows, and caused the ship to fill with water so fast that the crew had barely time to take to the boats, without water, provisions or clothing: the ship immediately went down, or disappeared in the fog. The crew continued in the boat until the afternoon of the 11th, when they were picked up by the Kingston, of Hull, bound to Pictou.

Ship Lowell, on the 10th of March, 1842, at 9 A. M., latitude 44° 15′, longitude 48° 30′, came in contact with a field of ice; was at that time steering W. N. W., with the wind. Tacked and stood to the eastward two hours, when she again tacked to the westward. At 2 A. M. again fell in with the ice. Continued beating to the southward, and falling in with the ice on the west tack till March 13th. Passed the southern extremity of the field in latitude 42°, longitude 49° 15′, having seen it extending in a N. N. E. and S. S. W. direction, nearly 150 miles.

A letter from Capt. Hosken, of the steamship Great Western, says: "April 18th, 1841, the ship steering west, at 6 P. M., first saw one iceberg on the starboard bow, at 7 30 passed it; at that time four or five others in sight; at 9 15 P. M. passed several small pieces of ice—slowed the engines. In a few minutes after, the ship was surrounded with light field ice, which appeared similar to a field I ran through on the 11th of February, 1839. This induced me to go slowly, with the hope of getting through, as I had done on that occasion; but by 9 30 finding it closely packed, and much thicker, prudence dictated our escape by the same channel we had entered. I then stopped and attempted to get the ship's head to the eastward, by turning ahead and astern until there was room for her to come round; in the course of this operation the ship had occasionally (at least) two streaks heel given by either wheel passing over large masses of ice. At 10 15, succeeded in getting the ship's head to the eastward, and by 11 P. M. entirely clear. From that time went slowly, passing several icebergs; the night at times very clear, the aurora bo-

realis very bright. At 3 30 A. M. of the 19th, again got embayed in the ice; stopped, hauled short round on our keel, and steered out E. by S., coasting the ice for five or six miles. At 4 20 kept her to the westward, running through innumerable icebergs until 8 30, when we passed the last iceberg and field of ice."

"When the sun arose the ice was visible as far as the eye could reach, in an unbroken line from N. E. by E., by the northward to N. W. by W.; at the same time, icebergs innumerable in every direction, forming one of the most magnificent sights I ever beheld."

"The first iceberg we saw was in latitude 43°, longitude 48° 30′; and the last in latitude 42° 20′, longitude 50°. I am quite sure there was an unbroken field of that extent; and from what I heard from Capt. Bailey, of the packet ship South America, I have no doubt the field ice extended, with very little break, to latitude 40° 30′, where Capt. B. fell in with it on the morning of the 18th. Several other ships also fell in with it in the same longitude, and were completely stopped, giving them an opportunity of killing seals, which were on it in great numbers. Some of the icebergs I estimate at little, if at all less than a mile long, and from one hundred and fifty to two hundred feet high. This field of ice was in large masses, some of them not less than twenty feet square by six feet thick or more."

"The temperature of the water, when within two miles of the first iceberg seen, fell suddenly from 50° to 36°; air 40° to 36°. When in the ice, the water was 25°, air 28°; during the remainder of the night and following morning the water was not higher than 30° nor the air higher than 32°. Immediately after passing the last ice the water became 36° and the air 42°."

Brig Cynosure, on the 23d, 24th, and 25th of July, 1842, latitude 42°, longitude 49° 30′, saw large icebergs, and was two days among the ice. Saw an island of ice that was estimated to be two hundred feet above the water, and saw several other islands in longitude 54°.

Ship England, Bartlett, April, 1842, latitude 41° 29′, longitude 49°, saw a large number of icebergs.

Brig Byron, Pierson, April, 1842, latitude 41° 18′, longitude 50°, saw four large islands of ice, one about 200 feet high and three miles long. Saw it 30 miles off.

British brig Peace, Robson, May 9th, 1844, made the ice in latitude 46° 52′, longitude 46° 30′, being bound to the Gulf of St. Lawrence, and was soon so completely imbedded in a large field of fragments that escape was impossible. She remained fast until the 13th, without injury, when in the night a gale of wind set in, crowding the large cakes down fast upon the sides and bulwarks of the vessel, which, from being in ballast, was soon stove in by the immense weight. On the 14th the small boats were got out and stocked with provisions, &c., and in the night of the same day the brig was abandoned. Captain R. with crew and boats remained upon the ice until the 18th, being unable to get into clear water, and on that day were taken off, in latitude 46° 50′, longitude 45° 42′, by the ship Copernicus, after much suffering.

Ship Burgundy, Wotton, in May, 1844, from the latitude 45° 30′, longitude 45°, to latitude 43° 30′, longitude 48°, was completely surrounded by icebergs and drift ice; lay to four nights, owing to the density of the fog; saw an iceberg two miles in length; no ice seen on the Banks.

Ship Virginia, Allen, latter part of January, 1844, was 34 hours fast in the ice. On the Banks, in a hurricane, lost foresail and main-topsail—saw large quantities of ice.

Ship Swanton, Heath, from 18th to 21st July, 1842, experienced thick foggy weather, latitude 43° and longitude 49° to 54°, passed upwards of 300 icebergs, some of them very large; came near being wrecked on them, having run between two large islands in the night, which nearly rubbed the ship on each side before we discovered them, notwithstanding all hands were upon the lookout.

Captain William Wier, bound eastward, gave the following account. On the 9th of March, 1787, latitude 42° N., longitude 55° 40′ W., was called by the mate to see a large ridge of breakers: altered my course from E. S. E. to S., the appearance of breakers being N. N. E., and trending from E. N. E. to W. S. W. March 11th, latitude 43° 34′, found myself in the midst of a large body of ice, trending E. N. E. and W. S. W.; soon got through. March 13th, latitude 44° 03′, at 8 A. M., made a large body of ice, extending beyond view from mast-head, and trending N. E. by E. and S. W. by W. At 10 P. M., met a larger body of ice, which entirely stopped the ship's way. On the morn-

ing of the 14th, found myself enclosed, and could see no water from mast-head, except one small hole, into which I pressed the ship; in 23 fathoms water on the Grand Bank. In this dismal situation lay with my sails hauled up, till 21st March, seeing no sea from main top-gallant-mast head. On the 17th went on the ice to take a view of an island of ice which bore from us W. S. W. We set out at 12 o'clock, and travelled one hour and thirty five minutes before we reached it. We found it aground in 25 fathoms, the main body passing fast by it, setting S. E. two and a half miles an hour, as I judged. On our return, having been absent three hours, the ice island bore W. N. W., having altered four points.

On the first day of January, 1844, Captain Burroughs, in the ship Sully, met with an iceberg in the Atlantic, in latitude 45°, longitude 48°. This is earlier in the winter than any other case which we have met with. Captain B. states that he had met with ice near this position on the first of February, on a former voyage.

In September, 1822, Captain Couthouy saw an iceberg aground on the eastern edge of the Grand Bank, in latitude 43° 18′, longitude 48° 30′. Sounding three miles inside of it, the depth was found to be 105 fathoms. In the month of August, 1827, the same observer, while crossing the Banks in latitude 46° 30′, longitude 48° W., passed within less than a mile of a large iceberg which was stranded in between 80 and 90 fathoms water. He was so near as to perceive, distinctly, large fragments of rock and quantities of earthy matter imbedded in the sides of the iceberg, and to see, from the fore yards, that the water for at least a quarter of a mile round it was full of mud, stirred up from the bottom by the violent rolling and crushing of the mass.

On the 27th of April, 1829, Captain Couthouy passed, in latitude 36° 10′ N., longitude 39° W., [probably south of the Gulf Stream,] an iceberg, estimated to be a quarter of a mile long, and from 80 to 100 feet high. It was much wasted in its upper portion, which was worn and broken into the most fanciful shapes. In 1831, at daylight of the 17th of August, latitude 36° 20′ N., longitude 67° 45′ W., upon the southern edge of the Gulf Stream, he fell in with several small icebergs, in such proximity to each other as to leave little doubt of their being fragments of a large one, which, weakened by the high temperature of the surround-

ing water, had fallen asunder during a strong gale which had prevailed from the southeast.*

Ship St. James, Meyer, July 12, 1844, latitude 44°, longitude 47° 12′, passed 12 large icebergs; July 20, passed 25 do.; and July 21, passed 30 do; latitude 43° 50′, longitude 52° 26′, saw the last of it.

John L. Hayes, Esq., in the Boston Journal of Natural History, states that Capt. Crocker, of New Bedford, measured with his sextant an iceberg which was aground on the Bank of Newfoundland, and found it to be half a mile long and two hundred and forty four feet high. Also, that Capt. Matthew Luce, of New Bedford, saw an ice-island of one hundred feet in height, aground in forty eight fathoms, on the Bank, and that the fishing vessels had sailed around it for thirty days.

Ship Switzerland, Knight, May 5th, 1844, in latitude 47° N., longitude 46° W., at 5 A. M. met with a perfectly solid field of ice, and the wind being N. E. hauled out to S. E. After coasting the ice forty miles, found it turned to E., and that the ship was embayed. Tacked to N., and after four tacks of one hour each, the wind hauled to S. W.; steered east a short distance from the ice. Afterwards turned to the south, and the wind hauling to the westward, steered S. S. W. for forty miles more, when the ice became broken, and very soon was entirely clear of it, having sailed eighty miles along an unbroken coast of ice, exactly in appearance like low land covered with snow. The wind continuing to the westward, saw more or less ice for three following days, but none south of latitude 44° 43′, nor west of longitude 49°.

Ship Formosa, Crawford, June 18th, 1842, latitude 38° 40′, longitude 47° 20′, saw an iceberg 100 feet high and 170 feet long.

On the passage out in the Acadia, on the 16th of May, in latitude 46°, longitude 47°, there were seen about 100 icebergs, some of them of large size, and one from 400 to 500 feet high, bearing so strong a resemblance to St. Paul's, that it was at once christened after that celebrated cathedral. The dome was perfect, and it required no extraordinary stretch of imagination to supply the turrets, pinnacles, and other parts of the building.

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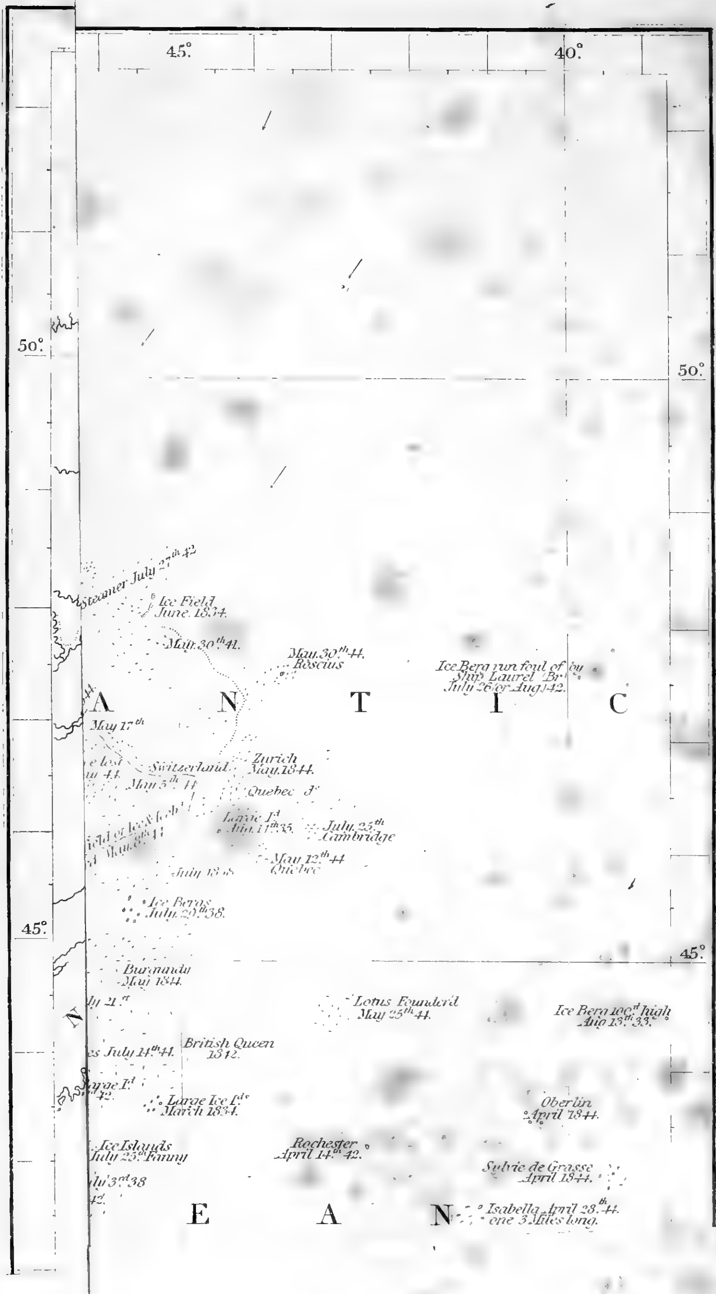
* See this Journal, Vol. XLIII, 1842.



45°
40°
50°
50°
45°
45°
Steamer July 27th 42
Ice Field June 1834.
May 30th 41.
May 30th 44. Roscius
Ice Berg run foul of by Ship Laurel Br. July 26 or Aug 1 42.
A N T I C
May 17th
Switzerland
Zurich May 1844.
May 5th 44
Quebec
Large Id Aug 11th 35.
July 25th Cambridge
May 12th 44 Quebec
Ice Bergs July 29th 38.
Burgundy May 1844.
Lotus Founder'd May 25th 44.
Ice Berg 100ft high Aug 13th 33.
British Queen 1842.
Large Ice Ids March 1834.
Oberlin April 1844.
Ice Islands July 25th Fanny
Rochester April 14th 42.
Sylvie de Grasse April 1844.
Isabella April 28th 44. one 3 Miles long.
E A N

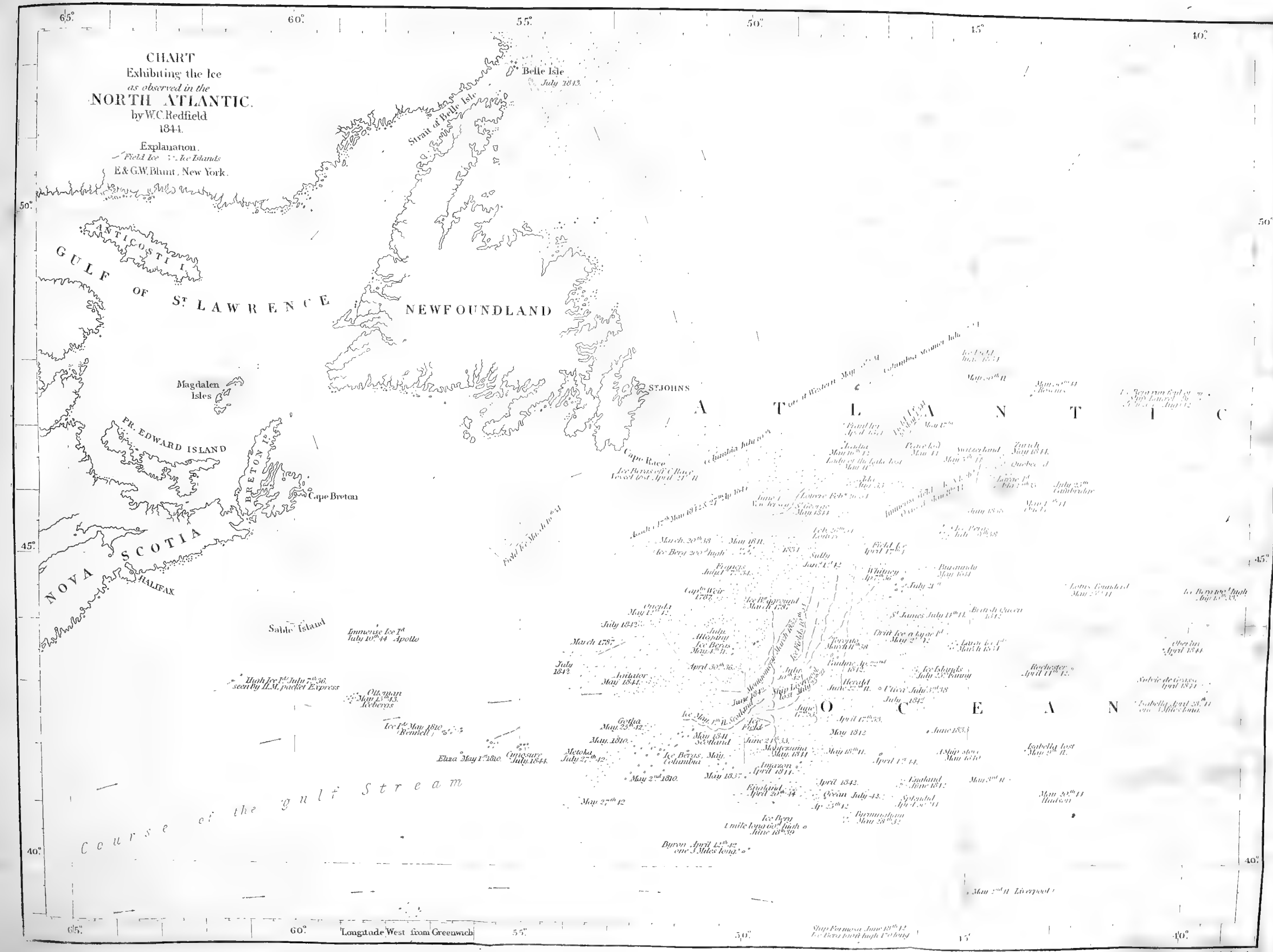


CHART
Exhibiting the Ice
as observed in the
NORTH ATLANTIC.
by W.C. Redfield
1844.
Explanation.
Field Ice
Ice Islands
E & G.W. Blunt, New York.
GULF OF ST LAWRENCE
ANTICOSTI I.
NEWFOUNDLAND
Belle Isle
July 1843.
Strait of Belle Isle
Magdalen Isles
PR. EDWARD ISLAND
CAPE BRETON
Cape Breton
NOVA SCOTIA
HALIFAX
Sable Island
ST JOHNS
Cape Race
ATLANTIC
OCEAN
Course of the Gulf Stream
Longitude West from Greenwich
Immense Ice Id
July 10th 44 Apollo
High Ice Id July 7th 36.
seen by H.M. packet Express
Eliza May 1st 1810.
Byron April 12th 42
one 3 Miles long.
Ice Berg
1 mile long 60ft high
June 13th 39
May 2nd 1810.
May 27th 42
C. Copley Sc.

On the homeward passage of the Acadia, on the 6th of June, the same object was seen, and the immediate exclamation on board was, "There's our old friend, St. Paul's." In the interim between the two views, the iceberg had drifted about seventy miles.*

An immense ice-island was seen on the 10th July, 1841, in latitude 43° 54′, longitude 58° 12′, by Captain Ricker, of the Apollo, at Boston. He reports that his thermometer fell when near it forty degrees.

It may be proper to state here, that many ice observations have been placed on the chart without a reference to the date or the vessel which reported them, and the want of room for the references has rendered this in a degree unavoidable. In compiling the chart, one hundred and fifty seven separate reports have been consulted, the general character of which may be estimated by the foregoing examples. Many other accounts might have been obtained, but it is believed that these are sufficient for an approximate estimate of the course and positions of the ice in various seasons, so far as relates to the routes of vessels coming from European ports.

On the Westerly tendencies of the Polar Ice-currents, and their Influence on the Gulf Stream.

In further noticing the westerly and southerly progress of the cold currents from the arctic regions, we avail ourselves of the researches of Rennell, who states that "a current from Greenland and the Arctic Sea joins the Gulf Stream on the east of the Grand Bank of Newfoundland, somewhere about latitude 44°, and between the meridians of 44° and 47°. In the month of May its direction has been found to be between S. W. by S. and S., and its temperature [apart from the ice] 43° to 47° of Fahrenheit. The temperature taken not far to the eastward of it was 62° to 63°, and an easterly current of 30 miles [per day] of the same water (i. e. gulf water,) was found at a distance from the eastern edge of the S. W. by S. cold stream. This is, doubtless, the current that brings down the ice from Greenland, &c., to the east of the bank of Newfoundland, and ice has been seen in the line of this very current, by different persons in different

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* English paper.

years. The navigators to Newfoundland and New England place the junction of these currents in about latitude 41°, longitude 49°, which shows how erroneous their ideas are on this subject."

Rennell likewise states that "there is also a smaller [?] current that passes down the coast of Labrador, and eastern side of Newfoundland, and carries ice in sight of the coast." He also says, that "it appears both from *his own* and other people's observation, that two distinct streams of ice exist; one on the east of the Bank, the other ranging along the coasts of Labrador and Newfoundland; and then obliquely across the Bank in a S. by E. direction; whilst that from Greenland, &c., runs between S. by W. and S. S. W. This last current appears to fall into the Gulf Stream about the latitude of 43° or 44°; and between the meridians of 45° and 50° W. The ice is, of course, carried into the Gulf Stream, where, from the warmth of its temperature, it must rapidly dissolve."* Rennell also states that many ice islands are found to the westward of the above, "in the line of the route from Halifax," and that they are often seen in the Strait of Belle Isle." We quote also the following:

"An experienced commander, long in the Newfoundland trade, has said that the branch current which appears to come from Hudson's Bay, always sets to the south-westward (perhaps S. S. W.,) off the eastern coast of Newfoundland: sometimes at the rate of two miles an hour; its strength, however, varying with the direction and force of the wind. Passing down the eastern coast of Newfoundland, it turns about Cape Race, and sets thence along the south side of the island, until it meets with the current from the St. Lawrence, [through the Strait of Belle Isle,] a little to the westward of St. Pierre and Miquelon Islands.

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* I have not sufficient knowledge of that portion of the Greenland current which lies north of the Banks, to enable me to determine if its course from the coast of Greenland be directly towards the Flemish Cap and the eastern side of the Grand Bank, or whether it may not fall in with the Labrador current in longitude 48° to 51° off the Strait of Belle Isle, or the southern coast of Labrador, running from thence southeasterly parallel to the coast of Newfoundland and outside of the Labrador current, carrying with it the belt or stream of ice which it brings from the Greenland seas. It is hoped that this point may be satisfactorily determined, and in the mean while I have ventured to indicate on the ice-chart, hypothetically, the more direct route to the eastern ice region, as being that of the Greenland current. W. C. R.

"When the Virgin Rocks, lying about 80 miles W. by S. from Cape Race, were surveyed in July, 1829, the current set over them to the W. S. W. at the rate of one mile an hour.

"It is probable that this westerly current impinges on the easterly one, and continues its course, with diminishing velocity, towards Breton Island, where it blends with that branch of the St. Lawrence stream which sets to the S. W. between Sable Island and Nova Scotia.

"The sea between the Grand Bank of Newfoundland and the Banks of Nova Scotia is distinguished by its drifts of *cold* water, varying with the wind and seasons."*

In further proof of the westwardly pressure of the polar current upon the American coast, we may state, on the authority of Captain Bayfield, the able officer who surveyed the Gulf and River of St. Lawrence, that "in spring the entrance and eastern parts of the Gulf are frequently covered with ice, and vessels are sometimes beset for many days;" and that "the reality of a current inwards through the Strait of Belle Isle, is confirmed by the presence of icebergs, which it transports into the Gulf in summer, against the prevailing S. W. winds, frequently carrying them as far as Mecatina, and sometimes even to the neighborhood of the east point of Anticosti." This last position is nearly 300 miles from the entrance of the strait, and almost half way to Quebec.

But even stronger proof of this inward pressure of the cold current into the gulf and estuary of St. Lawrence is found in the icy temperature of its deeper waters during the summer. Thus, in the middle of the estuary, off Matan, and more than 200 miles above the east point of Anticosti, on the 8th of July, Dr. Kelly found the temperature of the surface water 60°,—at 30 fathoms 35°,—at 50 fathoms 34°: the whole depth at that point being 132 fathoms. A subsequent trial in this portion of the river showed the surface water at 57°,—at half a fathom depth 44°,—5 fathoms 40°,—10 fathoms 38°,—100 fathoms 35°. At Tadousac, about half way to Quebec from the place of the last observation, Dr. Kelly found the temperature, in September, as low as 36°, after an easterly gale, which mingles the shallow stream of the surface with the deeper waters. Numerous other obser-

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* Purdy, in Rennell.

vations made at different times and places, during the survey, confirmed these results. Hence it appears that the drainage waters received by the rivers were discharged by means of the surface current, which swept over the cold subjacent waters that were brought in by the polar current and the flood tide. These facts should be remembered in viewing the relations of the polar currents to the Gulf Stream.

In relation to the southern outlet of the Gulf of St. Lawrence, it has been common for navigators and others greatly to overrate the proper *river* current of the St. Lawrence, in its extension southward of Breton Island and Nova Scotia. This fresh-water current, when compared with the branch of the polar current which joins it through the Strait of Belle Isle, is but of insignificant volume; and the current through this strait, in its turn, is but an ocean rill, when compared with the great volume and force of the cold currents which pass to the eastward and southward of Newfoundland.

It appears that Rennell was embarrassed in his investigation of the polar currents of this region, by admitting the assumption that a portion of the cold water, eastward of Newfoundland, was caused by the Bank itself. This hypothesis had been sanctioned by distinguished writers, but the observations and facts on which it was founded can now be satisfactorily explained by the admitted influence of cold currents, either superficial or sub-aqueous. He appears, also, to have viewed the Gulf Stream as opposing a direct obstacle to the further passage of the polar currents, but it appears to us, that the streams of existing aqueous currents are found intersecting each other, much in the same manner as they would pass through quiet waters, and that they quietly impose or imbed upon each other like as stratified currents of air, or lateral currents from the forks of rivers, are found to accommodate each other, in their respective courses. In these river cases, as apart from the extraneous deflection by the shores, while the original momentum of each stream continues, one of these may be borne away from its original course, and thus be resolved to a new or modified direction by the further progress of the current in which it is imbedded; but in such cases, a diversion of the course of the lower current does not usually take place.

In the case of ocean ice-currents which intersect a surface cross current, while the common *surface ice* conforms more or

less nearly to the new direction of the current on which it floats, the deeply immersed ice masses, having probably their greatest bulk immersed in the lower or deeper current, are thus resolved, by a real conflict of impelling forces, into a still different course, which conforms more or less nearly to that of the lower or subaqueous stream, according to the respective areas exposed to the action of the two currents, and their respective velocities. The geographical course of the body of the Gulf Stream, according to our best information, commonly touches the southern point of the Grand Bank in latitude 43° N., but the overflow or outspreading portion of the Stream often sweeps over the southern part of the Bank, as a surface current, when unimpeded by the ice. When the ice appears in great quantities it is probable that the Gulf Stream current coming from the west, carries the ice more eastwardly, from its previous southwesterly course. In thus yielding to the joint influence of the two currents, the surface ice assumes a new direction, towards the south or southeast.

Grounded icebergs, when quite stationary, afford the best means for observing the course of the common ice fields. The course of the ice-drift, within the influence of the Gulf Stream, doubtless varies at different times and localities, and must be greatly influenced by the depth of the floating masses. For in the case of icebergs or islands, particularly those which come down from the Greenland seas and pass eastward of the Grand Bank, their great depth subjects them to the continued impulsion of the lower or arctic current after they arrive within the influence of the Gulf Stream, the main part of the cold current passing beneath the warmer one, by means of its deeper position as well as greater specific gravity.

This may be shown from the cases before recited, of immense icebergs which have been impelled into the body of the Gulf Stream, where, instead of being drifted off to the eastward, in conformity with its course and with the like tendency of the prevailing winds, some of these floating islands have been forced across the body of the stream, and in some cases even far beyond its ordinary limits, to a latitude lower than that of the southern boundary of Virginia; as shown in the two cases given by Capt. Couthouy. The most eastward of these, in longitude 39°, and south from the usual eastern limit of the Greenland icebergs that arrive in the latitude of the Banks, was near seven degrees lower

in latitude than the southern extremity of the Grand Bank. The other icebergs noticed by him, in like latitude, and longitude 67° 35′, probably passed near to Newfoundland, and their position shows, in a more striking manner, the strong westwardly tendency of the polar current.

No impulsion but that of a vast current, setting in a general southwesterly direction and passing beneath the Gulf Stream, could have carried these immense bodies to their observed positions, on routes which cross the gulf current in a region where its average breadth has been found to be about two hundred and fifty miles.

The continued southwestern, and even more westwardly course of that portion of the polar current which is found southward of Newfoundland and Nova Scotia and west of the Gulf Stream, is conclusively shown by the two icebergs met with by H. M. packet Express, July 7, 1836, on the southern edge of the Sable Bank, about seventy-five miles southwest from Sable Island. The highest of these, estimated at 180 feet, was in latitude 43° 14′, longitude 61° 17′, the other, 150 feet high, in latitude 43° 09′, longitude 61° 26′. Owing to the great depth of these ice islands, they could not have passed through the Strait of Belle Isle, but must have been carried by the main current eastward and southward of Newfoundland to their observed position, which, by the nearest course, is near 500 English miles from off Cape Race, the southeast point of that island, in the direction S. 63° W., true meridian, or W. S. W. ½ S. Of the further extension of this portion of the polar current, in diminished force, along the coast of the United States and the western border of the Gulf Stream, as far as Cape Hatteras, if not to Florida, we have formerly spoken, in another place.*

The finding of a low temperature on the southern part of the Grand Bank, or even to the southward of latitude 43°, is not sufficient evidence of the entire absence of the Gulf Stream current: for the recent presence or proximity of floating ice must necessarily cause a great reduction in the surface temperature, and there is no natural process by which the cold water of the surface stream can be changed for warmer with a rapidity sufficient to preserve a temperature at all corresponding to the warm portions of the Gulf Stream.

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* This Journal, Vol. XXXII, p. 349.

It is well known that vessels in the northern part of the Gulf Stream, while steering parallel to its general course, have met with successive and striking changes in the temperature of the water and sometimes with ice, to the southward of Nova Scotia and Newfoundland, and in the proper line of the polar current. This is well shown in the journals of the ships Eliza and Grand Turk, as published in some former editions of the Coast Pilot. In latitude 41° 53′, longitude 56° 52′, the Eliza found the water at the depth of 70 fathoms two degrees warmer than that at the surface, the temperature of the latter being 40°, and an ice island bearing S. S. E., distant seven miles. S. S. W. and S. of the Grand Bank, and in nearly the above latitude, the Eliza again met with cold water and passed several ice islands. Rennell has also recognized these cold veins or bodies of water in the Gulf Stream. It appears, therefore, that in this portion of the Gulf Stream, neither its presence nor its actual limits can be determined with certainty by the thermometer, during the ice season.

It appears in the pages of the Coast Pilot, that Capt. Billings, in June, 1791, found the temperature of the water in the Gulf Stream to have fallen ten degrees, in latitude 39°, southward of the Bank, and that the like had been observed by Dr. Franklin and Col. Williams, in the same region. But, judging from the latitude, it is not improbable that these observations were made to the *southward* of the true border of the Gulf Stream. If this be the true solution, it is indicative of the partial re-appearance of the polar current, after passing beneath the Gulf Stream; and there is evidence of its further course to the S. W. and W. S. W., near the border of the Stream.

This leads us to notice a probable, if not a principal cause of the great variations, which have been reported, in the position and limits of the Gulf Stream, in its eastward progress. Rennell, we conceive, rightly supposes an *overflow* or outspreading of the Gulf Stream upon the ocean waters, as it proceeds in its course. Now we know, from well established cases, that overflowing streams, upon denser waters, are often very shallow; and Capt. Bayfield has shown, in the case of the estuary and Gulf of St. Lawrence, that the effect of a storm is to break up, for the time, this superficial current and amalgamate it with the deeper and colder waters. Hence we may infer, that in good weather and a smooth sea, the thermometric breadth of the Gulf Stream may

be far greater than in rough weather; and that it is most straitened in its limits immediately after the occurrence of a great storm.

Perhaps too little consideration has hitherto been given to the character and effects of the polar currents. These appear to be well worthy of the attention of both the navigator and the philosopher. We have seen that the moderate but unceasing flow of these currents often interposes an icy barrier in one of the most common routes of navigation. The observing geologist will also discern in the courses of the ice-currents of the Atlantic, both before and after their contact with the tropical stream, a striking coincidence with the directions of the two systems of striæ which mark the abraded surfaces of the continental rocks; the origin of which must be referred to the early and prolonged period when these rocks were situated beneath the ceaseless flow of the ocean currents.*

New York, December 30th, 1844.

Art. XVI.—*Notice of a mass of Meteoric Iron found at Cambria, near Lockport, in the State of New York;* by B. Silliman, Jr.

Nearly four years since I learned from an accidental interview with the Hon. Henry Hawkins in the cabinet of Yale College, of the existence in Lockport of a mass of iron which he supposed to be of meteoric origin. I took note of the facts, but circumstances prevented me from taking any further steps in the matter until the past summer. I then addressed a letter to Mr. H., requesting further information, and if possible, a piece of the iron. He at once sent me both, and the first sight of the portion sent, left no doubt of its meteoric origin—which conclusion was satisfactorily confirmed by a chemical analysis.

The following letter from Dr. May, of whom Mr. Hawkins purchased the mass, will convey all the information we possess of its discovery and history.

Lockport, August 28, 1844.

Senator Hawkins,—

Dear Sir—The mass of meteoric iron that I sold your brother for you, was found on the farm of William Temple in Cambria,

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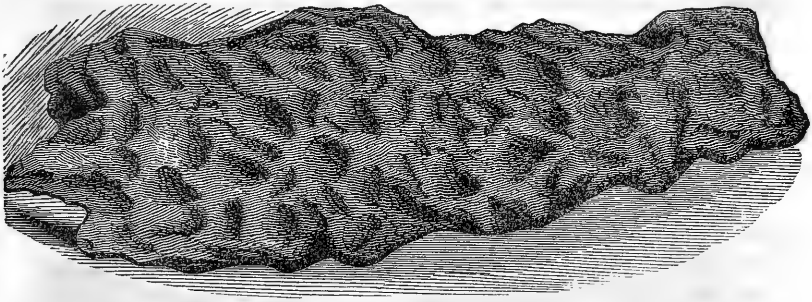
* This Journal, Vol. xliii, p. 152, and Vol. xlv, p. 326.

in this, Niagara County. It was found at the first ploughing of the field after the farm was cleared, and brought into town and sold as old iron—neither seller nor purchaser supposing it to be of any more value than so much cast iron, only thinking it curious that it should be found there. Dr. I. W. Smith saw it while it still lay on the store floor, and immediately purchased it as a specimen for his cabinet; and when the Young Men's Association was organized here, he placed that with an extensive collection of minerals in their rooms, where it remained until his death, after which I became the purchaser, together with his collection in mineralogy, and have had it in my possession ever since, until I passed it to your brother. Such is its history.

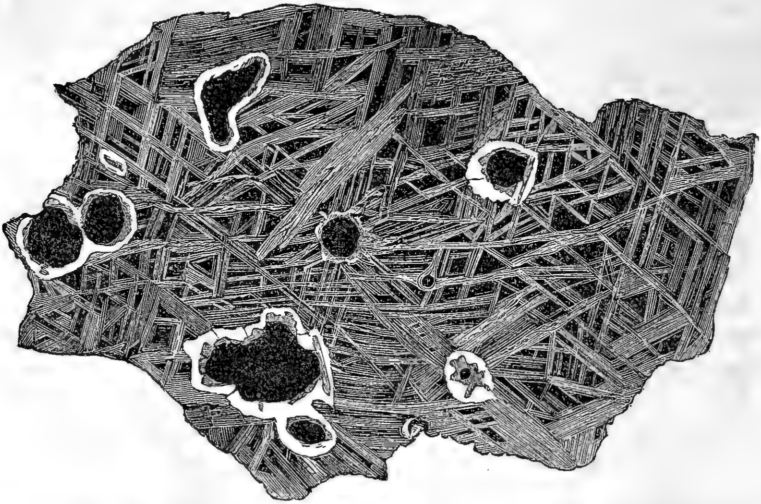
Very respectfully yours, O. W. May, M. D.

I subsequently purchased the entire mass of Mr. Hawkins, and the accompanying figure will convey a good idea of its general appearance.



It was nearly eighteen inches in length, and its greatest breadth about five and a half inches: its transverse section was rudely elliptical, as may be seen by the next figure, representing its internal structure, which is a faithful copy in size and outline. It weighed thirty six pounds avoirdupois. The deep cavities with which its surface was every where marked, were covered with a pretty thick film or coating of red oxide of iron, which cleaved off in scales under the knife, and the entire mass was much more deeply rusted than any other meteoric iron I have seen. No metallic brilliancy appeared on any part of the surface, except where a few points had been worn by friction. In hardness it was about the same as ordinary cast-steel before tempering, perhaps rather harder. It broke with the greatest diffi-

culty even in narrow shreds, and the surface of fracture was hackly, silver white, and strongly marked by crystalline structure. As I had determined to send a part of the mass to the British Museum through my friend, Prof. C. U. Shepard, an attempt was made to cut it in two on a machine for planing iron, but so much difficulty was found in effecting a section in that manner that it was thought best to put it in a turning lathe, in which the section was effected in about six hours. Numerous hard masses of sulphuret of iron (magnetic pyrites) destroyed the mechanics' tools with great rapidity. The surface of section was subsequently ground down and received a very high polish, the masses of yellow and white sulphuret of iron appearing in beautiful contrast with the dark lustre of the metallic iron. No time was lost in developing by means of dilute nitric acid, the crystalline structure of the mass, (the Widmannstättian figures.) It appeared on the first touch of the acid, and was deepened by continued action until the etching had become deep enough to receive ink and print an impression on paper; this was transferred by potash to a block of wood and engraved as in the accompanying figure, which is a faithful representation of the original.



The deep black spots represent the nodules of sulphuret of iron surrounded by a white ring of amorphous metallic iron, within which may be seen in some of the spots a ragged outline

representing the yellow sulphuret of iron, which appeared to be segregated chiefly about the outer limits of the magnetic pyrites; the latter was very rapidly acted on by the dilute etching acid, the yellow pyrites not at all, so that in taking an impression with ink from the surface, this difference was very apparent. Near the centre of the mass a long and irregular fragment of yellow pyrites alone appears. Microscopic points of the same could be discerned with a glass, scattered through the entire mass of magnetic pyrites. These masses of pyrites seem to have disturbed the regularity of the crystallization of the iron, and broken the continuity of the crystalline lines. To their abundance in this specimen, I attribute the numerous pittings of the surface. In the bottom of many of them I have observed it on clearing away the rust, and it will be seen in the figure that one of the masses on the left is in the bottom of a depression. The ease with which this mineral suffers decomposition and the acid which results, will easily account for the deep corrosion of the mass. Every part of the iron seems to abound equally in the sulphurets. This interesting specimen appeared then to be made up of three distinct mineralogical species; the metallic iron and two sulphurets of iron.

Chemical constitution.—A portion was dissolved in pure nitric acid; the solution was entire and speedy. Nitrate of silver produced a very feeble cloud of chloride—too feeble to be collected. A current of sulphuretted hydrogen produced no change in its passage through the solution in nitric acid, except a little sulphur set free, and hence was inferred the absence of copper, tin, arsenic, and all other metals likely to be present and precipitable by that reagent.

Ammonia threw down the iron, and the filtrate condensed by evaporation gave evidence by its feeble blue tint of a small quantity of nickel, which was free from cobalt. One grain of the iron gave

Iron, - - - - -	95·540
Nickel, - - - - -	5·037
	100·577

It has lately been shown by M. le duc De Lugnes, (Ann. des Mines, tom. v, p. 161,) that in some meteoric irons an additional quantity of nickel may be obtained by repeatedly redissolving

the oxide of iron and reprecipitating this even to the eighth time. Adopting this method, the precipitated oxide of iron was redissolved six times and the proportions obtained were as follows:

Iron, - - - - -	94·224
Nickel, - - - - -	6·353
	100·577

The sulphurets were examined also for the presence of tin, cobalt, copper, lead, arsenic, &c., but without success. They seemed to be only simple compounds of iron and sulphur. The specific gravity of the iron was 7·5257.

To determine more satisfactorily the presence or absence of chlorine, a piece of the iron (about one pound weight) was exposed in a humid atmosphere on a capsule under a bell glass for many days, and the little drops of water which trickled down and were caught by the capsule, were tested for chlorine with (as before) only a *very feeble* indication with nitrate of silver. My friend and pupil, Mr. D. Olmsted, Jr., made the analysis under my particular direction.

I have not had an opportunity to repeat on this specimen the interesting processes described by Mr. A. A. Hayes in the last number of this Journal, p. 149.

Yale College Laboratory, Jan. 28, 1845.

Art. XVII.—*Bibliographical Notices.*

1. *Report of the Commissioner of Patents for* 1844; by the Hon. H. L. Ellsworth. 8vo, pp. 520.—This report, like that which has preceded it from the same distinguished source, contains a great fund of information on subjects connected with Agriculture and the Arts, and their progress in our country. We quote from it the following account of *a new magneto-electric machine* by Prof. C. G. Page.

"In 1838, Prof. Page published in Silliman's Journal an account of an improved form of Saxton's magneto-electric machine, doing away with many existing objections, and furthermore rendering it at once a useful instrument, by a contrivance for conducting these opposing currents into one channel or direction, which part of the contrivance was called the unitress. The current produced in this way was capable of performing the work, to a certain extent, of the power developed by the galvanic battery; and the machine was found adequate to furnishing

of shocks for medical purposes, for exhibiting the decomposition of water, furnishing the elements oxygen and hydrogen at their respective poles, and producing definite electro-chemical results. These two last results could not be obtained without the aid of the unitress. But, with this improvement, the instrument was still wanting in one property of the galvanic battery—viz. that property which chemists call quantity, or that power upon which depends its ability to magnetize, and also to heat platinum wires. This last property has been given to the machine by the recent contrivance of Prof. Page. The machine, in its novel construction under his improvement, developed what is called, by way of distinction, the current of intensity, but had a very feeble magnetizing power. By a peculiar contrivance of the coils, (not to be made public until his rights are in some way secured,) the current of quantity is obtained in its maximum, while, at the same time, the intensity is so much diminished that it gives scarcely any shock, and decomposes feebly. It has been successfully tried with the magnetic telegraph of Prof. Morse, and operates equally well with the battery. It affords, by simply turning a crank attached to the machine, a constant current of galvanic electricity; and as there is no consumption of material necessary to obtain this power, it will doubtless supersede the use of the galvanic battery, which, in the event of constant employment, would be very expensive, from the waste of zinc, platinum, acids, mercury, and other materials used in its construction. It particularly recommends itself for magnetizing purposes, as it requires no knowledge of chemistry to insure the result, being merely mechanical in its action, and is always ready for action without previous preparation; the turning of a crank being the only requisite when the machine is in order. It is not liable to get out of order; does not diminish perceptibly in power when in constant use, and actually gains power when standing at rest. It will be particularly gratifying to the man of science, as it enables him to have always at hand a constant power for the investigation of its properties, without any labor of preparation. We notice among the beautiful results of this machine, that it charges an electro-magnet so as to sustain a weight of one thousand pounds, and it ignites to a white heat large platinum wires, and may be used successfully for blasting at a distance; and should government ever adopt any such system of defence as to need the galvanic power, it must supersede the battery in that case. Prof. Page demonstrates, by mathematical reasoning, that the new contrivance of the coils affords the very maximum of quantity to be obtained by magnetic excitation."

2. *Final Report on the Geology and Mineralogy of the State of New Hampshire, with Contributions towards the Improvement of Agri-*

culture and Metallurgy. By CHARLES T. JACKSON, M. D. Published by order of the Legislature; Concord, N. H., Caroll & Baker, Printers. 376 pp. 4to, *with several lithographs and wood-cuts, maps and sections.*—We only announce the appearance of this volume at the present time, intending to give an analysis of it in the next number. The volume is highly valuable, alike for its geological, mineralogical, and agricultural information. The chemist, mineralogist and geologist, practical and theoretical, are happily united in its author, and the work exhibits strongly the advantage of this union. The single discovery of the ore of tin in New Hampshire, is more than a return for the expenses of the survey. The work is got up in a handsome style; though from Concord, N. H. it will bear comparison with the best works from the Boston press.

3. *The* TACONIC SYSTEM, *based on Observations in New York, Massachusetts, Maine, Vermont, and Rhode Island;* by Prof. EBENEZER EMMONS, M. D. 67 pp., 4to, with six lith. plates. Albany, 1844.—The Taconic System of Prof. Emmons includes slates, limestones and sandstones lying, in his view, beneath the oldest and inferior members of the New York system, and resting unconformably upon the primary schists. This position, the fossils, and the peculiarity in the relative arrangement of the members of the series, are considered as sustaining the independence of this system. Although the conclusions may not be received by all geologists, the work with its fine illustrations is an important contribution to the science. We have no space in this number to present our own views upon the subject.

4. *American Quarterly Journal of Agriculture and Science;* conducted by Dr. E. EMMONS and Dr. A. J. PRIME. Vol. I, No. 1. Jan. Feb. and March. 184 pp., 8vo. $3.00 per annum.—This is the title of a quarterly Agricultural Journal, which has just appeared at Albany. It embraces a wider and higher scope than the other agricultural periodicals of the country, aiming not only to disseminate scraps of information and gleanings from other Journals, but also to give series of articles in successive numbers upon subjects of interest, which together shall constitute complete treatises upon the same, including all the useful information relating to them, that may be required by the practical agriculturalist. From the ability of the editors and the appearance of the present number, we feel assured that the work will prove a most valuable acquisition to the American farmer.

5. *Report on American Coals to the Navy Department of the United States.* By WALTER R. JOHNSON; 600 pp. 8vo. Washington, 1844. —These investigations, of which the results are here detailed, were

made to ascertain the effective power of the different varieties of coal in producing steam, and in a general application to the arts. The experiments have been made on a scale commensurate with the importance of the subject, and with every attention that could secure perfect accuracy to ascertain the evaporative power. From one to six trials were made with the several varieties of coal, 1500 pounds being sometimes consumed in each. The results are tabulated with fullness and perspicuity. We defer to another number a fuller account of this very valuable Report.

8. *Vestiges of the Natural History of Creation.* 288 pp. large 12mo, 1845. New York, Wiley & Putnam.—This work commences with a spirited sketch of the astronomical system according to the Nebular theory. The author then proceeds to give an outline of the structure of the earth and the various steps in the progress of its formation, both as regards the origin of its rock strata and the successive changes in animal and vegetable life. Discussions with regard to the origin and development of animals, the early history of mankind, the mental constitution of animals, and the general condition of the animated creation, constitute a large part of the work; and the whole is presented in a novel and interesting light, with many bold conceptions and startling opinions. Although we cannot subscribe to all of the author's views, we would strongly recommend the work to our readers.

MISCELLANIES.

DOMESTIC AND FOREIGN.

1. *Remarks on Uranium and Pyrochlore, in reply to Prof. Shepard, pp.* 177–179 *of this volume;* by J. E. Teschemacher.

Gentlemen—In the last number of the American Journal of Science and Arts, I observe a communication from Prof. C. U. Shepard, accusing me of claiming the priority of the discovery of uranium, at Chesterfield, Mass., such priority belonging to himself. His proof is the publication of it under his name in the 2d vol. of Prof. Hitchcock's last report on the Geology of Massachusetts, page 704.

I think little of the merit of the discovery, but much of the imputation of claiming that to which I am not entitled, and therefore alone request the favor of room for a short reply.

The minutes of the Boston Society of Natural History,* of the 7th April, 1841, show that my paper announcing the above fact was read at their public meeting held that day—this is always considered equivalent

* These minutes are always printed and circulated.

to a publication; but the truth is that I had discovered the mineral several months previously, and had distributed nearly all my specimens among my friends. My whole paper was published in the Society's Journal, Vol. 4, page 35, under the date of the *6th April*, 1841. Prof. Hitchcock's report was only published the following November. These facts amply justify the statement in the excellent mineralogical volumes of Messrs. Alger and Dana.

With reference to Prof. Shepard's charge in the same communication, that I have been unjustly harsh to him in my remarks on Pyrochlore, I need make no reply to those who have read the controversy.

In the case of pyrochlore in question, he seems to have narrowed the claim of distinction between this mineral and his microlite, to the single character of specific gravity, the first being 4·2, the second 5·5, which difference he is unable to reconcile. Probably this arises from his having seen so few crystals of this rare mineral from Chesterfield. After having supplied Mr. A. A. Hayes with about *fifteen* grains for his analyses, and distributed specimens to most of my friends here and in Europe, I have still left more than five or six times as many crystals as he avers to have seen.

In these the eye alone can discover considerable diversity in composition, the texture varying from sub-granular to the vitreous character of those from the Swedish localities; the external layers of some are translucent yellow, the internal parts being a dark brownish black, and vice versa; others are from a red brick color to a transparent yellow—all agreeing in form.

Pyrochlore is essentially a columbate of lime; but the specific gravity of specimens from different, nay even from the same localities, must vary, as it is mixed with varying quantities of accidental and different ingredients; that from Fredericksvarn, according to the elaborate analysis of Mr. Hayes, containing besides columbic, chiefly titanic acid. All columbic minerals are of a higher specific gravity than titanic and the other accidental mixtures of pyrochlore, columbite rising as high as 6·1, while anatase, a pure oxide of titanium, is as low as 3·8. The Chesterfield pyrochlore, specific gravity 5·4, contains nearly 80 per cent. columbic acid, (A. A. Hayes,) while that from Sweden, according to the same authority, specific gravity 4·2 contains only 53 per cent. columbic and 20 per cent. titanic acids. This is alone sufficient to account for the difference in the specific gravity of the mineral from each locality; but there are several other considerations both chemical and crystallographic, on which I will not dilate now, that render this character of little value in mixed minerals.

If Prof. Shepard, however, following up the discovery of columbate of lime, will proceed to ascertain its true composition and specific

gravity, and then compare the proportionate quantities in pyrochlore from different localities, he will no doubt find that a proper investigation of the character of specific gravity, like that of its chemical and its crystallographic characters, will result in the complete identity of pyrochlore and microlite.

It is very possible that the recent discovery of *niobium* and *pelopium*, two new metals in the columbite of Bodenmais by Rose, may add new interest to this columbate of lime from Chesterfield.

Yours truly, J. E. Teschemacher.

Boston, 1st March, 1845.

2. *Note on Pseudomorphism;* by James D. Dana.—The following fact with regard to the solution of silica, from the Report of the British Association for 1840, (2d part, p. 125,) has an important bearing on pseudomorphism, and especially on the principles discussed in the January number of this Journal, as well as other changes in which silica is concerned. The experiments described were made by Mr. J. Jeffrys, and expressly to ascertain the effect of water at a high temperature on silica and siliceous minerals. A large boiler used for vitrifying brown stone ware was employed, heated by four exterior furnaces, each six feet long and five wide. Between each of the furnaces and the kiln a deep pit was made, into which three feet of water was put, which was renewable from without.

"Some feldspathic and siliceous minerals were placed in the way of the current, just inside of the kiln, and upon some of the arches a few articles of ware were placed, that any action upon them might be observed. Below a full red heat little effect was perceived, but at a heat above that of fused cast iron a rapid solution of mineral matter took place. This heat was continued ten hours. When the kiln was opened, more than a hundred weight of mineral matter, though in a very dense and refractory form, had been dissolved, and carried away in the vapor. The wall was eaten away, and presented a rough, and quite unglazed surface like loaf-sugar partially melted by water, or as if eroded by some animal; and nothing of the smooth glazed surface, which invariably attends the action of alkali on a siliceous surface. Some articles of ware in the hottest situations were partially eaten through; but on the uppermost arch, where the heat was only a full red, a curious phenomenon appeared. The articles there had received, exterior to their own brown gloss, and loosely encrusting it, a complete frosted coat of silica, having the appearance of a candied surface. It was manifestly a precipitation from the mineral vapor, and in fact a hoar-frost of silica. There was probably from half an ounce to an ounce on each vessel, and several pounds altogether were thus precipitated;

but by far the greater part of the mineral vaporized was, as might be supposed, carried away in the current. Since this powerful action was apparently entirely due to the presence of water, there being at all times the same quantity of alkali present in the fuel, whatever that might have amounted to, producing no such effect, the experiment seems to establish, at very high temperatures, a powerful action of water on siliceous matter. To attribute the action to alkali would not lessen the difficulty, both because under perfectly similar circumstances, when there was no water, no effect was produced, and because each pound of alkali would have had to dissolve, perhaps, forty pounds of silica."

In connection with this subject it should be remembered how important a part siliceous animalcules have probably played in the changes which fossils have undergone. The fact that some kinds of flint and opal have been shown to contain siliceous animalcules thickly disseminated, and the vast quantities in which they are collected together in some deposits like that of the tripoli stone, suggest this as a very important source of silica; and especially in such earthy sedimentary rocks as show by their constitution, that they probably formed a proper habitat for the growth and reproduction of these animalcules. The decomposing vegetable or animal would naturally gather them around it, for they appear in myriads wherever decomposition is in progress; and the waters slowly dissolving their siliceous casts as they die, especially if aided by some increase of temperature, might thus be prepared to silicify the fossil. Yet this principle cannot be appealed to in all cases. The vast quantities of silicified wood, we find in some regions—especially in regions where there is evidence of igneous action, evince that hot siliceous solutions, the necessary result of subaqueous igneous action, must have been engaged in producing the changes. They are now going on in Iceland. Oregon abounds through its basaltic regions, in evidences that such an agent has been in extensive action; and so also do most regions of ancient and modern igneous action.

3. *Gold of North Carolina;* in a letter from J. H. Gibbon to the Editors, dated United States Branch Mint, Charlotte, N. C., Jan. 10, 1844.—We receive here increasing quantities of gold from mines in this state and that of South Carolina—occasionally, also, from Georgia and Alabama. Gold bullion, to the value of 272,000 dollars was deposited here for coinage during the last year, exceeding by nearly 100,000 dollars the deposits of any preceding yearly period.

The promptitude with which individual miners ascertain, and receive the value of their gold, is extensively appreciated. Capital and labor are now employed more considerately in mining than has always been the case.

The sands of the Catawba river, and other streams, passing through the gold regions, have lately been worked with good prospect of profit. An original by the name of Gibson, has "entered" large quantities of the land *under* the waters of the Catawba, and claims a title from the state. He employs flat boats, or scows, which are pushed out into the river, and detained in their station by poles at the corners. Three men are employed in each boat, who manage two long-handled shovels of peculiar construction, for the improvement of which, Gibson has applied for a patent. The shovels are worked by a long crop-handle which acts as a lever, and the shaft has several projections, upon which the foot of the workman is placed, according to the depth of the water, to assist in penetrating the sand and gravel at the bottom of the stream. A man uses one of these shovels on each side of the boat, while a third hand pulls at a grape vine, fastened near the lower end of the handle, to raise the shovel over the side of the boat, into which he empties the contents. Every evening the accumulations are washed at the shore side by a rocker, attached to which is a drainer with quicksilver, to amalgamate the particles of precious metal. The quality of this gold brought in the amalgam to our mint, proves to be above standard.

The workmen reside in shanties on the bank of the river, by permission of the proprietors of adjacent lands. The same spots are worked over and over again from day to day, as the descent in the river causes a rapid filling up of the cavities made by the shovels. There is a difference of opinion with regard to the right of title to such an "entry,"—but I am informed, that the deeds of landholders, along the river banks do not claim the river, and leases have been taken when the supposed richness of the sands demanded extraordinary security.

As the Catawba is not navigated, no obstruction is given to a public highway; indeed the operations can go on very well without any interruption to the use of the waters. Gibson says he "don't care for the river, all he claims is the land under it!"

4. *Geological observations on the region near Centerville, Alabama,* —condensed from a letter to the Editors.—Centerville is situated at the falls of the Cahawba. An extensive limestone formation commences two miles up the river, on the east side. Four miles up the river the country is hilly, and east of the hills there is a valley of one thousand to one thousand five hundred acres, throughout which a bed of coal extends. Iron ore—supposed to be brown hematite—exists here in great quantity, and the place is peculiarly well adapted for furnaces. On the west side of the river there is a valuable marble quarry, in which there is a vein of sulphate of barytes a foot wide. Extensive coal fields are found farther up the river, with mines of cobalt and

hematitic iron; those of cobalt ten or twelve miles, and those of iron about twenty miles. The iron ores are inexhaustible, and already two forges are at work. Coal is close at hand, and the iron manufactured is said to be of superior quality.

5. *An Intermittent Spring.*—In a letter from Dr. E. G. Edrington of Pittsburgh, we are informed of an intermittent spring nearly opposite Pittsburgh, issuing from the bore of an abandoned salt well. The water at intervals of about three weeks, was thrown to a height of twenty or thirty feet, accompanied with an issue of inflammable gas, to the accumulation of which, the jet is attributed. This ejection would continue for two or three hours, and then the water would sink below the surface. While the pump was in operation, before abandoning the well, similar jets were thrown out sometimes to the height of forty feet, whenever it was worked after the repose of a day or two. The bore passes through a bed of coal eighteen inches thick, at a depth of one hundred and thirty three feet; another of eleven feet, at one hundred and eighty feet; a third of four to four and a half, at two hundred and eighty feet; and others of about the same thickness at three hundred and eighty, four hundred and eighty, five hundred and forty, and five hundred and eighty feet; and one of nine inches, at six hundred and eighteen feet. A thin stratum of limestone was found a short distance below each stratum of coal, except the last.

6. *New Metals, Pelopium and Niobium*, discovered by M. H. Rose. (Abstracted from Comptes Rendus, Dec. 1844, T. xix, p. 1275.)—These new metals were detected in the Columbite of Bavaria. The oxyd of niobium much resembles columbic acid, and is called niobic acid. Columbic acid when heated becomes slightly yellow, while niobic acid takes a very deep yellow color; both, however, become colorless on cooling. *Columbic acid*, after calcination, is without lustre; *niobic acid* on the contrary has a high lustre like titanic acid when precipitated by ammonia and calcined; but it remains colorless, while titanic acid takes a brownish color. The red cyanid of iron and potassium gives a white flocculent precipitate with a solution of *columbate of soda;* and a deep yellow one with *niobate of soda.* If a plate of zinc be plunged into a solution of *columbate of soda*, rendered acid, nothing takes place, except after some time, when a white precipitate forms, which is columbic acid; in a solution of *niobate of soda* rendered acid by a little sulphuric or muriatic acid, the zinc produces a blue precipitate, which in time passes to brown.

The oxyd of *pelopium* resembles columbic acid; but has not yet been fully examined.

The name *Niobium* is from Niobe, the daughter of Tantalus, and the name *Pelopium* from Pelops, a son of Tantalus.

Rose states that the columbite of Bodenmais, Bavaria, and North America, have the same crystalline form with wolfram. He also remarks that columbic acid, niobic acid, titanic acid, and binoxyd of tin, have probably the same atomic composition, and many characters in common.

7. *New Metal Ruthenium;* by Prof. Klaus of Casan. (Chem. Gazette, Feb. 1, 1845.)—This metal was discovered by Prof. Klaus in the platinum residues, from which it was obtained as a salt, along with salts of iridium and osmium, by fusing the residues with nitre. The metal as reduced was a blackish gray powder, lighter than iridium. It belongs to the platina group of metals, and its chlorids resemble those of iridium. The highest chlorid is of a beautiful orange-yellow color, and affords, with ammonia, when in solution, a precipitate of a black oxyd, while the solutions of the chlorids of the allied metals afford no precipitate with ammonia at the ordinary temperature. The metal as well as its compounds, yields when ignited with nitre, a blackish green mass, which dissolves in distilled water to a beautiful orange liquid, composed of the metallic acid and potash, (rutheniate of potash.) This solution blackens organic substances, and is decomposed by alcohol, the acids, &c. with the deposition of a velvet-black compound of the oxyd with potash, soluble in muriatic acid and forming thus the orange-yellow chlorid. The chlorid after a long continued action of sulphuretted hydrogen, deposits a sulphuret which is at first brown, and finally black, the solution taking a splendid azure-blue color. The oxyd of ruthenium was first detected in an ore of titanium and zirconia by Osann. Osann failed to obtain the metal, but named the oxyd, oxyd of ruthenium. Prof. Klaus has extracted the oxyd from the same ore.

8. *Musical Tones produced by Magnets*, by Dr. Page, in a letter to the Editors.—From the London Electrical Magazine for January, 1845, it appears that the production of musical tones in magnets or iron bars, by making and breaking galvanic contact with coils so arranged as to act upon the magnets or bars, has of late excited some attention with European philosophers, and the date of the observation of this singular fact is fixed as far back as 1842. If the readers of your Journal will recur to Vol. xxxii, p. 396, for 1837, and Vol. xxxiii, p. 118, for 1838, they will find that I have there described this singular phenomenon of the disturbance of molecular forces by the disturbance of magnetic equilibrium, together with several modes of producing musical tones.

9. *Atomic Weights of Copper, Mercury, and Sulphur;* by Drs. Erdmann and Marchand. (Ann. de Ch. et de Phys. t. x.)—

Copper, - - -	396·6
Mercury, - - -	1250·9
Sulphur, - - -	200·07

The atomic weight of copper was determined by the reduction of the oxyd, according to the plan adopted by Berzelius; that of mercury from peroxyd of mercury, and that of sulphur from vermilion or sulphuret of mercury.—(Cited from the Chemical Gazette, Sept. 15, 1844.)

10. *De Vico's Comet.*—This comet announced, Vol. XLVII, p. 419, as discovered by Mr. H. L. Smith, Sept. 10, 1844, (and erroneously designated *Faye's* comet at page 219 of this volume,) was first detected at Rome, August 22, 1844. Many sets of parabolic elements of this comet have been computed. The elliptic elements computed by *Faye*, and given in our last number, he has compared with forty positions of the comet as observed at Paris, and also with observations made at Altona, Hamburg, and Manheim. In the *Comptes Rendus Acad. Sci.* Dec. 9, 1844, *Faye* gives as the result, the subjoined *third* set of elliptic elements, expressing his confidence in their great precision.

Perihelion passage, [Paris, m. t.]	1844, Sept. 2·483952.	
Longitude of perihelion, . . .	342° 31′ 15″·2	Mean equinox of Jan. 1, 1845.
Longitude of ascending node, . .	63° 49′ 30″·6	
Inclination, ...	2° 54′ 45″	
Excentricity, ...	0·61725587	
Semi-axis major, ...	3·0994629	
Time of revolution, ...	5 yrs. 5½ mos. or 1993 days.	

This comet is probably identical with that of 1585, observed by Tycho-Brahé and calculated by Halley.

11. *Southern Comet of December,* 1844.—This comet must have been, during the months of December and January last, a conspicuous and brilliant object to the inhabitants of the equatorial regions. It was probably visible to the naked eye as early as the 1st of December, and may have been discovered at some southern observatory several weeks before. As the comet was telescopically visible down to the middle of March, opportunity has been given to secure an extensive series of observations. In December last (day not stated) the length of the tail is reported to have been 20°. From observations of Jan. 27, and Feb. 1 and 7, taken at the High School Observatory, Philadelphia, the following parabolic elements of the comet were computed by Prof. E. Otis Kendall, and published Feb. 11, 1845, in the United States Gazette.

Perihelion passage,	1844, Dec. 20·102786,	Berlin m. t.
Long. of perihelion, - -	277° 57′ 12″·2	m. eq.
" of asc. node, - -	117° 42′ 24″·1	Feb. 1.
Inclination, - - - -	46° 14′ 19″·0	
Perihelion dist., - - -	0·1054316.	
Motion, - - - -	Direct.	

Mr. Joseph S. Hubbard, (recently of this city,) in a letter dated Feb. 13, gives the following parabolic elements of this comet, computed from observations made Jan. 30, Feb. 2 and 6, at Washington City, D. C., by Capt. Frémont and himself.

Perihelion passage,	1844, Dec. 14·951451	Berlin m. t.
Long. of perihelion, - -	292° 20′ 26″·4	m. equin.
" of asc. node, - -	117° 30′ 13″·7	Feb. 2.
Inclination, - - -	46° 7′ 20″·3	
Perihelion dist., - - -	0·2198425.	
Motion, - - - -	Direct.	

The annexed parabolic elements have been derived from observations at Yale College Observatory, made by Mr. Francis Bradley, Feb. 12, and March 6, taken in connection with Prof. K.'s observation of Jan. 27;—the measurement of the same date made here by Mr. B. being unavailable for want of the position of the star with which the comet was compared.

Perihelion passage,	1844, Dec. 14·5700	Gr. m. t.
Long. of perihelion, - -	294° 20′ 30″	m. equin.
" of asc. node, - -	118° 21′ 15″	Jan. 1, 1845.
Inclination, - - - -	45° 40′ 37″	
Perihelion dist., - - -	0·232994.	
Motion, - - - -	Direct.	

12. *D'Arrest's Comet.*—A telescopic comet in the constellation *Cygnus*, was discovered by M. D'Arrest at Berlin, Dec. 28, 1844. The following elements have been computed by M. Rumker.

Perihelion passage,	1845, Jan. 12·3528	Greenwich m. t.
Longitude of perihelion, - -	97° 59′ 35″	
" of ascending node, -	337° 7′ 37″	
Inclination, - - - - -	47° 4′ 21″	
Log. per. dist., - - - -	9·95756.	
Motion, - - - - -	Direct.	

These elements have some analogy to those of the comet of 1779; but it is unsafe hastily to affirm an identity.—*L'Institut*, Jan. 22, 1845.

13. *School for the study of Elementary and Analytical Chemistry*, by Dr. C. T. Jackson, Boston.—We would call attention to Dr. Jack-

son's proposals to establish a school of chemistry, published in our advertising sheet. Dr. Jackson is well known at home and abroad for his analytical researches, as well as for his geological and mineralogical explorations. The conveniences of an excellent cabinet of minerals, a well furnished laboratory, under the direction and instruction of one so skilled in practical as well as theoretical science, afford a valuable opportunity for those who may wish to acquire a knowledge of the principles of elementary and analytical chemistry and its application to the arts.

14. *Geological Survey of Canada.*—A bill has just passed the House of Assembly of Canada, making provision for a geological survey of the province. A sum not exceeding two thousand pounds is to be appropriated annually for five years, and such a number of persons selected for the work as shall be necessary to make an accurate and complete geological survey.—*Chr. Guard. for Feb.* 26, 1845; *Toronto, Canada.*

15. *A Geological Survey of Vermont* is about to be made by State authority, under the superintendence of Prof. C. B. ADAMS of Middlebury College, Vt.

16. *Lyceum of Natural History in New York.*—This institution we are happy to learn, has been relieved from its financial embarrassments, and has been provided with a splendid suite of rooms in the building recently known as the Stuyvesant Institute, No. 659 Broadway. We understand that it is expected to resume the publication of the Annals of the Lyceum at an early period. The following gentlemen were recently elected officers for the year 1845.

President.—JOSEPH DELAFIELD.
1st Vice President.—JOHN AUGUSTINE SMITH.
2d Vice President.—ABRAHAM HALSEY.
Corresponding Secretary.—JOHN H. REDFIELD.
Recording Secretary.—ROBERT H. BROWNNE.
Treasurer.—JACOB P. GIRAUD, Jr.
Librarian.—ROBERT H. BROWNNE.

Publishing Committee.—JOHN LECONTE, ABRAHAM HALSEY, JOHN TORREY, WM. C. REDFIELD, JACOB P. GIRAUD, Jr.

17. *The Association of American Geologists and Naturalists*, holds its *sixth* annual meeting at New Haven, during the week commencing with Wednesday the last day of April. The place is a convenient centre for the reunion of the science of our country and a full meeting is expected. Naturalists as well as geologists are generally invited, and communications on any branch of Physical science will be received.

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